ELECTRICAL ENGINEERING

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THE COVER: Speech input from the tape recorder to the analog-digital converter in the background is checked by M. V. Mathews and E. E. David (both seated) as H. S. McDonald and R. E. Graham watch for signal variations on the oscilloscope screen on the converter at Bell Telephone Laboratories. Story page 1068.

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New amplifier battles "noise"

Four-stage junction diode amplifier was developed at Bell Telephone Laboratories by Rudolf Engelbrecht for military applications. Operates on the "varactor" principle, utilizing the variable capacitance of diodes. With 400-mc. signal, the gain is 10 db. over the 100-mc. band.

The tremendous possibilities of semiconductor science are again illustrated by a recent development from Bell Telephone Laboratories. The development began with research which Bell Laboratories scientists were conducting for the U. S. Army Signal Corps. The objective was to reduce the "noise" in UHF and microwave receivers and thus increase their ability to pick up weak signals.

The scientists attacked the problem by conducting a thorough study of the capabilities of semiconductor junction diodes. These studies led to the conclusion that junction diodes could be made to amplify efficiently at UHF and microwave frequencies. This was something that had never been done before. The theory indicated that such an amplifier would be exceptionally free of noise.

At Bell Laboratories, development engineers proved the point by developing a new kind of amplifier in which the active elements are junction diodes. As predicted, it is extremely low in noise and efficiently amplifies over a wide band of frequencies.

The new amplifier is now being developed for U. S. Army Ordnance radar equipment. But it has numerous other possibilities. In radio astronomy, for example, it could be used to detect weaker signals from outer space. In telephony, it offers a way to increase the distance between relay stations in line-of-sight or over-the-horizon communications.

BELL TELEPHONE LABORATORIES

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Electric Power for Future Flight Vehicles

M. C. DEMLER

The era of the Space Age presents a tremendous challenge to the electrical engineering profession. Electric power is essential not only in the launching of satellites or space vehicles, but also in providing the energy for instrumentation and habitation, as well as propulsive power.

NEVER BEFORE has there been so clearly indicated the need for an interplay and exchange of communication between our scientific and engineering community and elements of the Government responsible for laying the framework of our defense programs. We find ourselves on the threshold of an era comparable to the turn of the century when the future role of electric power was beginning to take shape but the "wherewithal" required lay ahead. The know-how to forge our needs of the future was beginning to crystallize and to grow into increasing technical capabilities.

An essential difference between these two eras is the existence today of a greater incentive to forge ahead. We are exploring space not to satisfy our quest for knowledge alone. We are driven by a greater need, which is to insure our very survival. To succeed, we must excel in technological skill over those who would seek to destroy us.

In this time period, manned and unmanned flight potential is moving higher in the atmosphere and beyond into free space. A U. S. Air Force pilot has already penetrated over 99% of the earth's atmosphere. For all practical purposes, air and space merge, forming a continuous and indivisible field of operations. Just as in the past when our capabilities to control the air above the earth permitted our freedom of movement on the land and seas between, so in the future will the capabilities to control space permit our freedom of movement on the surface of the earth and through the earth's atmosphere.

If past history is a criterion, the military can be expected to play a significant role on the team for the exploration of space. From the time of heroic Marco Polo, seemingly fantastic legends are shown to be founded on even more fantastic fact—evidence of what the mind and will of man are capable of in order to blaze new trails across the globe. A history exists of such men—Columbus, Lewis and Clark, and Richard Byrd, to mention a few—along with our more modern military explorers of space.

In support of our national objectives, the next decade will require a continuing advancement in aircraft and missile operation, coupled with technical breakthroughs in achieving control of space. Man is continually probing space for scientific data, investigating the fringes of space for establishing boost-glide techniques, and conducting unmanned and manned orbital flights and subsequent lunar flights for eventually enabling sustained operations from the moon. These efforts must be progressively undertaken as we advance technologically. However, we must identify those areas requiring significant state-of-the-art advancements, and separate these efforts from those indicating only marginal advancement or improvement. We can maintain leadership in this technological race only if an optimum alignment of resources (both manpower and dollars) is constantly pursued. By optimum alignment, I am referring to hardware programs versus programs of the exploratory type leading to significant payoff areas for future hardware programs.

AN AGGRESSIVE TECHNOLOGY PROGRAM

THE AIR FORCE is fully cognizant of the need for an aggressive technology program, if this nation is to survive. Our planning must prevent our resources from being exhausted on immediate day-to-day hardware problems. We must avoid complete reliance upon crash hardware programs at the sacrifice of an orderly and energetic scientific and engineering program exploring and tapping the vast depths of the unknown. We must recognize and strongly support the basic spade work leading to significant state-of-the-art advancements. This does not imply that our day-to-day hardware problems must be neglected. What I am saying is that we must look at our over-all effort, and insure that an optimum share of available resources contribute to significant payoffs. In this connection, the Air Force technical program is oriented to two approaches: (1) evolutionary and (2) revolutionary. The evolutionary part of the program represents an orderly projection of the state of the art in specified technical areas toward our ultimate objectives. This progression does not take the form of small incremental increases, but is a series of significant, logical steps.

A large percentage of our resources is devoted to the revolutionary aspects of the program. This part of the program accelerates the state of the art by maximizing

Essentially full text of an address presented at the AIEE Summer General Meeting and Air Transportation Conference, Buffalo, N. Y., June 22-27, 1958.

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the effort in selected areas of research and development which may lead to "breakthroughs" of great payoff as soon as possible. This approach contains the scientific gambles that must be made at the risk of higher probability of failure than the more conservative and methodical evolutionary procedures. In view of the intense scientific competition for technological supremacy, these gambles are a must if eventually we are to succeed in maintaining supremacy for the free world. Success in the revolutionary program may render related evolutionary work obsolete. Such obsolescence must be recognized continuously and the work eliminated from the program.

I am sure that it is not necessary to emphasize the ever-increasing role of electric power. Reliable and predictable power in sufficient quantities to actuate propulsion devices, flight vehicle components, and electronic and communication equipment is a mandatory requirement to aeronautical and astronautical operations. The significance of power systems for accomplishing these functions has led to the formulation of a program for "secondary power," which is defined as "all power necessary to operate air vehicles, space vehicles, and extraterrestrial sites, exclusive of that power supplied as the primary propulsive force." Secondary power, therefore, includes not only electric power, but also other forms such as hydraulic and pneumatic.

As mentioned previously, the next decade will require a continuing advancement in aircraft and missile operation, coupled with technical breakthroughs in achieving control of space. In this connection, it is essential that adequate and timely electric power capability be provided for these operations. Electric power is required throughout the useful life of the vehicle. It is required to energize the multiple types of communication, electronic countermeasure, intelligence gathering, and other special equipment. Transformation of the unmanned satellite or free-space vehicle into a manned system will require electric power to energize equipment to create and maintain a habitable environment and provide human comfort services. It is apparent that the electric power needs for future flight vehicles are becoming highly critical. Without adequate power to operate this mission equipment, space vehicles become nothing more than orbiting debris.

TYPICAL EXAMPLES

A MORE SPECIFIC LOOK at electric power requirements necessitates a review of some typical potential mission categories. The boost-glide vehicle, such as the *X-15*, which is a forerunner of possible vehicles to come, is characterized by rather large power requirements for a relatively short duration—30 minutes to a number of hours. Requirements to actuate control surfaces during these periods may range from 20 to 200 hp, depending upon vehicle size and configuration.

Regarding satellites, power requirements range from 10 watts to several kilowatts, depending upon the mission. The power needs for manned satellites will be somewhat greater, probably from 3 to 20 or more kw. Some of these vehicles may be required to remain aloft only a matter of days to achieve their purposes, while others may have durations up to and beyond one year.

Power requirements for lunar missions are dependent on many factors. Duration is dependent upon the choice of the propulsion technique, and may vary from a few to 100 or more days. The vehicle may require as much as 50 to 100 kw for mission equipment and over a megawatt of electrical power if ion propulsion is used.

Regardless of the mission category, great strides are necessary to improve reliability, life, and duration of electric power. A foremost consideration pertains to energy conversion processes. No longer will we enjoy the ability to "borrow" power from the propulsion system for the purpose of generating electric power. New energy sources from which electric power can be derived must be studied. Ideally, these sources would be available in free space.

And now, what does the Air Force need or want from the electrical industry? There must be prototypes leading to significant capabilities in the electric power area. Air Force research and development funds are programmed to support this effort. However, it is recognized that sufficient resources are not available to support the total effort needed. As in the past and now to a greater degree, the Air Force is looking to industry to share the cost.

Problems being faced today in flight within the atmosphere are highlighted by the high-temperature environment of operation. In some higher-performance aircraft, certain equipment items are beginning to become marginal from the cooling standpoint because of the temperature produced by high-speed flight. High temperature causes insulation breakdown and failure of lubricants, bearings, brushes, and solder in electric power equipment. Material problems relating to these failures must be overcome through rigorous programs seeking new materials and new techniques. The electrical industry, in addition to adapting available materials to their designs, should strengthen the search for advanced materials. The impact of a technical breakthrough in materials is so far-reaching that we cannot afford a limited effort in this area.

The design of the electric power utilization equipment in many instances has been based either on misinformation or lack of information regarding the actual type of electric power provided on air vehicles. As a result, there exist today various types of equipment requiring input power of forms which differ from that generated for the primary electric system. Thus, it has become necessary to resort to the use of power-conversion devices. These devices are parasitic to the electric system and are costly in terms of weight, bulk, and system reliability. Every effort should be made by industry to design electric equipment within the standard parameters established.

The area of space operation offers the greatest challenge to the electrical industry. As stated previously, we no longer will have the luxury of obtaining power from the main propulsion system. The absence of a

source of mechanical power, coupled with the requirement for a high degree of reliability, for light weight, and for long life, necessitates a new look at electric power sources. Such technical possibilities as solar-energy conversion, thermal-energy conversion, nuclear-energy conversion, chemical-energy conversion, and others must be advanced for application to specific mission category flight vehicles. This involves a double-barrel approach—that is, research and development in the area of the energy source as well as the conversion process—because the over-all efficiency must be considered in the final analysis.

RELIABILITY

In addition to these basic problem areas, future flight vehicle operation will require more reliable electric power. We need to approach 100% reliability for space operations. Also, attainment of a lightweight system is essential. By the end of the decade, we should achieve 250 kw-hr per pound of equipment.

These are just a few of many problems requiring a solution by the electrical industry. Even more could be said about other problems such as conversion of direct current to alternating current, quality power, power distribution and utilization, and the hyperenvironment which must be an ever-present consideration.

In seeking solutions to these problems, we cannot expect to find the answer within any one house. The scope and complexity of what we are seeking require a team effort. The Air Force fully appreciates this aspect of research and development programs and intends to further with increased vigor the close Air Force–industry relationship which has existed in the past. However, I feel that much can be done within industry to effect cross-fertilization between the various engineering professions. This must be done if an adequate and timely solution is to be found for the problems which lie ahead.

In summary, I want to emphasize again that we are in an era which is most challenging to the electrical engineering profession. With the advent of the Space Age, electric power is assuming a role of great importance in that once the main power plants have launched the satellite, or space vehicle, secondary power becomes primary in supplying the energy for instrumentation and habitation, as well as the propulsive power, where required. The need for significant advancements in the state of the art necessitates that both industry and the Air Force pursue a vigorous program leading to their attainment.

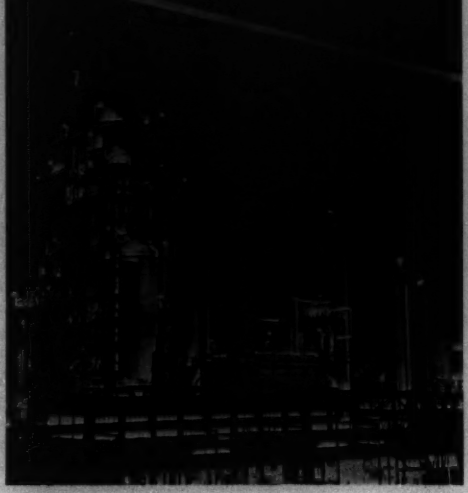
Aircraft Beacon Atop Industrial Site

A superpowerful revolving aircraft beacon, the first to be installed as a visual identity marker for an industrial site, has been turned on by the Wilshire Oil Company of California to provide a new landmark in light, signaling the growth and progress of the southern California area and of this progressive independent oil company.

Its light is said to be visible from the air as far away as 300 miles, and from 40 miles away on the ground. The searchlight, located atop the company's 20-story-high catalytic cracker petroleum processing unit, located in Los Angeles, makes one complete sweep of the horizon every minute.

The 500-million candle-power beacon was designed, built, and installed by Federal Sign and Signal Corporation, Chicago, Ill., creator of similar revolving searchlights which have become landmarks in other areas of the nation. Beacons of this type are atop the Empire State Building in New York, N. Y., The Republic National Bank Building in Dallas, Texas, and the Commonwealth Life Insurance Building in Louisville, Ky.

Weighing more than 2 tons, the 5-foot diameter searchlight is so delicately balanced that it requires only a ⅓-hp electric motor to revolve it. The Civil Aeronautics Authority has welcomed the installation as an additional navigational aid.



A Protection Plan for Distribution Feeders

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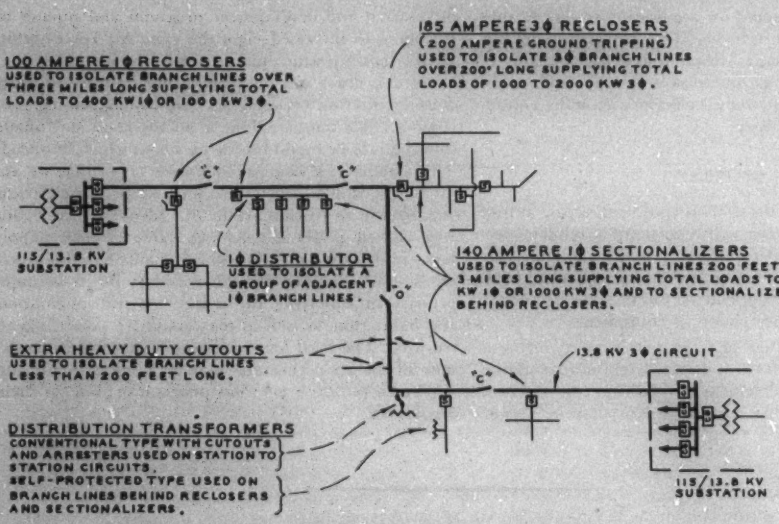

185 AMPERE 3Φ RECLOSERS
(200 AMPERE GROUND TRIPPING)
USED TO ISOLATE 3Φ BRANCH LINES OVER 200' LONG SUPPLYING TOTAL LOADS OF 1000 TO 2000 KW 3Φ.
100 AMPERE 1Φ RECLOSERS
USED TO ISOLATE BRANCH LINES OVER THREE MILES LONG SUPPLYING TOTAL LOADS TO 400 KW 1Φ OR 1000 KW 3Φ.
115/13.8 KV SUBSTATION
1Φ DISTRIBUTOR
USED TO ISOLATE A GROUP OF ADJACENT 1Φ BRANCH LINES.
140 AMPERE 1Φ SECTIONALIZERS
USED TO ISOLATE BRANCH LINES 200 FEET TO 3 MILES LONG SUPPLYING TOTAL LOADS TO 400 KW 1Φ OR 1000 KW 3Φ AND TO SECTIONALIZE BEHIND RECLOSERS.
EXTRA HEAVY DUTY CUTOUTS
USED TO ISOLATE BRANCH LINES LESS THAN 200 FEET LONG.
13.8 KV 3Φ CIRCUIT
DISTRIBUTION TRANSFORMERS
CONVENTIONAL TYPE WITH CUTOUTS AND ARRESTERS USED ON STATION TO STATION CIRCUITS.
SELF-PROTECTED TYPE USED ON BRANCH LINES BEHIND RECLOSERS AND SECTIONALIZERS.
115/13.8 KV SUBSTATION

Fig. 1. One-line diagram showing plan in action.

MANY UTILITIES are increasing distribution system primary circuit voltages as a means of supplying continually growing loads in urban areas. However, the fundamental advantage of higher-voltage feeder design, the ability to serve more load in larger areas, prevents the substation circuit breaker and its associated relays from providing adequate protection for the entire feeder. Automatic line-sectionalizing devices must be provided to restrict outages to a portion of a feeder area, thereby limiting the customers without service and reducing the area that must be patrolled to locate the fault.

Planning the protection for a feeder requires the consideration of many factors including system voltage, normal load currents, inrush currents, maximum and minimum fault currents, number of branches, lengths of line, types of load, and equipment to be protected. To eliminate the need for the individual analysis of each feeder and proposed sectionalizing point, the Public Service Company of Colorado has developed a plan for installing automatic line sectionalizing devices on its 13.2-kv feeders in the metropolitan Denver area. This plan provides for the protection of the feeder main from each of its branch circuits by automatic reclosers, sectionalizers, or cutouts depending upon the load, exposure, and length of the branch. Only one size each of single-phase sectionalizers, single-phase reclosers, 3-phase reclosers, and fuse cutouts is used.

The Public Service Company of Colorado designs its 7.6/13.2-kv feeders for loads of 6,000 kw or 7,500 kva. The main circuits, which are of 4/0 copper or its aluminum equivalent, can be tied through normally open field switches to adjacent feeders. Distribution in an area is served by laterals tapped to the main circuit. These laterals constitute most of the exposure to the feeder and are subject to the largest percentage of faults.

Fig. 1 illustrates the protection of a feeder in accordance with the rules of the plan. Some of the benefits achieved through this plan are:

1. Engineering time is conserved.
2. Stocking is reduced as only one size of each device is used.
3. Uniform and consistent protection is achieved.
4. Protecting all feeder laterals means only the feeder main must be patrolled when a fault has locked out the station breaker.
5. One station feeder breaker relay setting co-ordinates with either of the reclosers or the sectionalizer.
6. One sectionalizer size co-ordinates with the station breaker and both of the reclosers.
7. Load areas can be switched from feeder to feeder or to other substations without co-ordination being lost.

Digest of paper 58-174, recommended by the AIEE Transmission and Distribution Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Feb. 2-7, 1958. Published in AIEE *Power Apparatus and Systems*, Aug. 1958, pp. 486-94.

J. R. Hayden, J. E. Martin, and R. L. Tilson are with the Public Service Company of Colorado, Denver, Colo.

Managing Research Laboratories

T. M. LINVILLE
FELLOW AIEE

Research laboratories of the type set up for the purpose of developing knowledge and understanding in the natural sciences generate innovations and are an important element in progressive businesses. Studies made in the electrical manufacturing industry give evidence that research is gaining appreciation as an operation in itself and that evaluation and management of this work is rapidly progressing.

A STATEMENT appeared in one of the popular business journals recently saying that, "Like the aircraft industry, the electrical industry spends more on research than on plant expansion. In aircraft, roughly $3.80 on research for every dollar on capital expansion; in electrical machinery $2.80."[1] With this statement in mind, it seems paradoxical to assert that every dollar spent for research should generate around $3 of spending for engineering, and $10 for plant expansion. The difference lies in what is meant by "research."

The terms "research" and "engineering" encompass the whole scope of basic and applied science. Engineering produces processes and marketable products. Research produces knowledge and understanding. At one point it touches engineering, because if the knowledge is to be put to use it must be taught to engineers, and the teaching requires demonstration or application. Hence, the first fission reactor, the first man-made diamond, the first manufactured polymers, and the first transistors all were produced by scientists—and the new scientific knowledge was passed on to engineers.

The businessman who runs a manufacturing firm may depend upon the universities and the Government for research and employ technical people only to do engineering work. He may say there are no proprietary rights to acquire in basic science, that only the applications are patentable and valuable. Accordingly, he will set up a laboratory mainly to do materials testing and product development.

Such a laboratory is the very kind that *should* be attached directly to a manufacturing business. Indeed, in a large company, these laboratories need to be decentralized to the same extent as the manufacturing and engineering operations are decentralized. The laboratories are part of the business operations, as our hypothetical manufacturer realized.

Essentially full text of conference paper 58-1031, presented at the AIEE Pacific General Meeting, Sacramento, Calif., Aug. 19-22, 1958. Recommended for publication by the AIEE Management and Research Committees.

T. M. Linville is with the General Electric Company, Schenectady, N. Y.

But what about the *research* laboratory? Does it belong in industry at all? If so, should it be detached from operations? Obviously, to be worthwhile, somehow it must be connected to operations. How should this be accomplished?

Suppose we consider the problem of the business manager whose goal is to have his company make a better return on sales and investment than is the standard for his industry. His company is to be a leader. In the final analysis, this goal can be achieved only by introducing innovation. Markets will control wages and prices to such an extent that the greatest leverage lies in leadership. This may be introduced in any or all functions of the business, but it is especially powerful when directed to product leadership. Here research is a tremendous asset. The sequel to research is invention, and the sequel to invention is opportunity for leadership and better profits. For those who aspire to leadership, then, research belongs in industry.

But the cost of some kinds of research can be large. Good scientists, when provided with the facilities and materials for their work, can cost $40,000 a year. To assemble a hundred of these can take $4 million. If the research bill takes 10% of a company's profits, the net earnings must be $40 million. If the net sales is 10%, the sales billed must amount to $400 million per year. Clearly, research which requires substantial manpower is a job for big business. This assumes that effective research does require substantial manpower so that many scientists can interact with one another. Furthermore, it assumes that research, in addition to engineering, is not an essential function or "way of life" except for companies in the industry whose purpose is to lead and to grow through diversification.

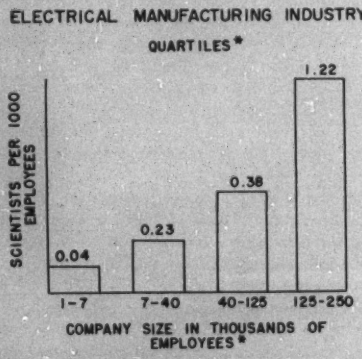
Fig. 1, taken from a recent study, shows how scientists are employed in the electrical manufacturing industry in relation to the size of companies. Companies smaller than about 20,000 employees do not contribute significantly to the expansion of basic knowledge and have relatively few scientists engaged in this work.

DETACHMENT FROM OPERATIONS

CASE STUDIES of large companies show varying degrees of detachment of research laboratories from business operations. Consider a hypothetical case in which there is a high degree of detachment involving several industrial corporations having common owners and combined size sufficient to support substantial research. Each has its own engineering laboratory for applied research and development. The owners have established still another corporation for research. Its purpose is to produce knowledge that will generate invention and thus

expand and feed the business corporations. The corporations have a "board-of-direction" of full-time executives who constitute the officers of a nonoperating corporation through which the ownership is consolidated. Of course, the components could be divisions of a single corporate structure. But thinking of them as corporations suggests a high degree of decentralization having no management above the level of the operating components, only direction and appraisal exercised for the owners by executives and services officers not acting as operating managers.

As a hypothesis, then, a high degree of organizational detachment is valuable, because in a business organization of limited scope as to markets and products, business managers pay close attention to applied research and development in order to produce products for market. These managers do not, however, have the



(*1/4 OF EMPLOYEES IN INDUSTRY ARE IN COMPANIES OF LESS THAN 7,000 EMPLOYEES; 1/4 ARE IN COMPANIES HAVING FROM 7,000 TO 40,000; etc.)

Fig. 1. Research in relation to size of company.

breadth of goals of owners, particularly owners who possess not one but a number of business organizations which, together, cover a wide range of markets and products. Such owners, for instance, are looking for new business opportunities outside of existing business interests.

FUNCTIONAL ORGANIZATION STRUCTURE

THE PRODUCTION AND MARKETING of basic knowledge is like a business in many of its aspects. It takes owners, customers, employees, buildings, tools, supplies, and money. The functions to be performed include research itself, operation of facilities, marketing, and personnel and financial work, with subfunctions listed in Fig. 2. Research, of course, is the primary function in terms of size, cost, and production of end results.

Research is generally conducted on a project basis, with the projects falling into a variety of natural group-

RESEARCH	FACILITIES OPERATION	MARKETING	PERSONNEL OPERATION	FINANCIAL OPERATION	LEGAL OPERATION
THINKING	MAINTENANCE	TEACHING	WAGE ADMIN.	COST ACCOUNTING	EVALUATION
EXPERIMENTING	SHOPWORK	ANALYZING	SALARY ADMIN.	PAYROLL ACCOUNTING	ANALYZING
REPORTING	PURCHASING	REPORTING	UNION RELATIONS	AUDITING	COUNSELLING
APPLYING	ENGINEERING	INFORMING	SAFETY	ANALYZING	PATENTING
EVALUATING		PUBLISHING	HEALTH	REPORTING	DEFENDING
TESTING		MEETING	RECRUITING	COMPUTING	LICENSING
DEMONSTRATING			SECURITY	BUDGETING	
INVENTING					

Fig. 2. Functions and subfunctions in research laboratories.

ings. These groupings are the building blocks of organization structure. Two kinds of groupings are common: (1) by sub-*fields* of work—for example, physics of semiconductors, physics of generation of light, etc., or organic and inorganic chemistry, etc., and (2) by sub-*kinds* of work—for example, theoretical, experimental, application, evaluation, or feasibility studies.

In some large laboratories, the research function is found to be organized in several components, each of which reports to the manager of the laboratory. When the individual in charge of each of these components is responsible for the research function alone, the other functional components shown in Fig. 2 report directly to the manager. In very large laboratories, this simple organization scheme makes the number of components reporting too large to be managed. Hence, some division of the simple structure is found in these cases.

To meet this situation, the larger laboratories generally have the other functions report to another manager (Fig. 3B). However, this manager does not have authority over the research component managers, since this would make him an assistant director (Fig. 3A), resulting in two directors rather than one. Actually the responsibility for all functions is delegated to each research component manager. Then the services manager operates in a responsible capacity within his own realm,

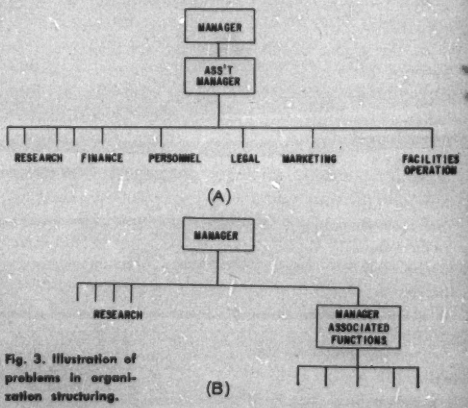


Fig. 3. Illustration of problems in organization structuring.

supplying the various research managers with services to their order, with costs quoted in advance to be charged to their accounts. These observations are schematically true rather than completely true for the details of practice.

Although the position of assistant manager shown diagrammatically in Fig. 3 is found in a few laboratories, it has the disadvantage that in reality there are either two persons dividing authority over the same individuals or an extremely short span of managerial responsibility for the manager. There are, of course, a multiplicity of successful ways of operating and no two laboratories can be found to be organized alike.

PERSONNEL, SPACE, AND COST DATA

INFORMATION has been published about the people, facilities, and money required to launch and operate a research laboratory employing any given number of scientists.[2-9] A small part of the data is illustrated in Fig. 4. The data is by no means precise, being given in terms of broad ranges, but such data can be useful in preparing estimates and in comparing one's organization with others. Furthermore, it leads to more precise data.

More recent data were supplied by five large research laboratories in industry late in 1956. These are illustrated in Figs. 5 through 9, inclusive. For each item of data, the average, minimum, and maximum figures for the five laboratories are given. The data includes the distribution of personnel and floor space by functions; the investment in land, buildings, and equipment per employee; and the direct, indirect, and total costs for people, materials, and fixed expenses. No account is taken of differences in the laboratories either in character, age of facilities, or accounting or classifying practices. Raw data of this character would be expected to have wide variations, especially in the smaller elements.

Experience with the data in the raw condition helps to determine what should be done to make it more accurate. For example, the differences in what each item of data stands for at the various laboratories could be analyzed and taken into account. This is a time-consuming job, however, of considerable cost and doubtful real value. An alternative is to take each elemental function —groundskeeping, for example—and express its cost by a hypothetical formula in terms of variables and coefficients, as though it were independently isolated from other functions. Data on the cost of performing the function and on the corresponding values of the independent variables are next collected from a dozen sources. The formula is then tested for fit with the data and is reconstructed until the fit is accurate and the coefficients and deviations are evaluated. By addition to the elemental formulas, a total model is thus constructed for laboratories and other kinds of plants, and the status and progress of laboratory or plant operations can be inspected in relation to the model. This work is purely exploratory at present. Its objective is to provide information calling attention to deviations rather than to develop measurements or standards.

	MIN.	MAX.	MEAN
GROSS SQ. FT. PER SCIENTIST	500	1500	–
LAB. SQ. FT. PER SCIENTIST	150	300	–
RATIO: SCIENTISTS TO TOTAL EMPLOYEES	.25	.67	–
GROSS INVESTMENT PER SCIENTIST	$ 8,600	$34,900	$21,900
ANNUAL EXPENSE PER EMPLOYEE	6,900	10,200	9,100
ANNUAL EXPENSE PER SCIENTIST	13,900	42,600	25,400

Fig. 4. Published figures, 1948-54.[1-8]

	AVERAGE	MAX.	MIN.
GROSS FLOOR SQ. FT. PER EMPLOYEE:	385	465	304
GROSS FLOOR SQ. FT. PER SCIENTIST:	1221	1830	952
LAB. FLOOR SQ. FT. PER SCIENTIST:	505	666	379
RATIO: SCIENTISTS TO TOTAL EMPLOYEES:	.32	.38	.26
RATIO: OTHER EMPLOYEES TO TOTAL:	.68	.62	.74
PERCENT EMPLOYEES IN RESEARCH FUNCTION:	60	72	48
PERCENT EMPLOYEES IN OTHER FUNCTIONS:	40	52	28
GROSS INVESTMENT PER EMPLOYEE:	$15,500	$19,750	$11,300
GROSS INVESTMENT PER SCIENTIST:	$49,100	$73,500	$35,800
ANNUAL OPERATING EXPENSE PER EMPLOYEE:	$13,400	$18,700	$10,700
ANNUAL OPERATING EXPENSE PER SCIENTIST:	$42,100	$56,000	$28,200
RATIO: SALARIES AND WAGES TO TOTAL EXPENSE	.55	.63	.43
RATIO: INDIRECT EXPENSES TO DIRECT SALARIES AND WAGES	1.48	2.07	.89

Fig. 5. Survey data for large research laboratories in industry, 1956-57.

The collection of information is simplified in this method because the separation of elements is made at the source. The uncertainty as to purity and homogeneity of the data which usually plagues such cost information is minimized. When data collected from miscellaneous sources fits with a formula, rather than exhibiting a gun-shot pattern of deviations, it seems evident that independent operations in different locations under different conditions tend to approach the same standard of performance. Likewise, deviations stand out and draw attention to exceptional performance, which then can be studied to determine whether it is poor or good.

ORGANIZATION STRUCTURE AND LABORATORY SIZE

LABORATORIES vary in size from less than a hundred employees to several thousand. Circumstances will vary, and there is no optimum or maximum size to fit all cases. However, one unit suggested for size is that which corresponds to an organization which one manager can manage effectively, including managing all of the principal functions shown in Fig. 2. An analysis of the organization structure and size of a number of laboratories indicates that departure from the basic functional organization structure of Fig. 2 definitely occurs in large laboratories. Size at which departure from the simple functional organization structure is necessary, then, is one point at which separate laboratory facilities

	% (AVG.)	% (MAX.)	% (MIN.)
RESEARCH:	60.0	72.0	48.0
FINANCIAL:	2.2	3.6	1.1
LEGAL:	1.5	2.5	0.2
PERSONNEL:	2.5	4.4	1.2
FACILITIES OPERATION:	12.8	17.7	5.4
LIBRARY OPERATION:	1.5	4.9	0.3
PUBLISHING OPERATION:	1.5	2.5	0.3
SHOP OPERATIONS:	11.2	21.8	6.7
PURCHASING AND STOCKKEEPING	6.8	14.7	2.7
TOTAL	100	—	—

Fig. 6. Survey data for distribution of employees by functions, 1956-57.

	% (AVG.)	% (MAX.)	% (MIN.)
RESEARCH	40.4	44.0	38.4
FINANCIAL	0.6	1.1	0.1
LEGAL	0.5	0.9	0.2
PERSONNEL	1.3	2.2	0.6
LIBRARY OPERATION	1.3	2.0	0.9
PUBLISHING OPERATION	1.7	2.0	1.2
FACILITIES OPERATION	41.5	45.2	37.7
SHOP OPERATION	6.5	10.5	3.9
PURCHASING AND STOCKKEEPING	6.2	10.9	1.2
TOTAL	100	—	—

Fig. 7. Survey data for distribution of floor space by functions, 1956-57.

	$ (AVG.)	$ (MAX.)	$ (MIN.)
LAND	$ 282	$ 386	$ 85
BUILDINGS	9,143	12,450	6,300
EQUIPMENT	5,636	9,280	3,400
TOTAL	$15,060	$19,000	$10,700

Fig. 8. Survey data for investment in dollars per employee, 1956-57.

	% (AVG.)	% (MAX.)	% (MIN.)
SALARIES, WAGES, AND BENEFITS	61.6	69	52
PURCHASES	24.9	36	15
TAXES, DEPRECIATION, AND INSURANCE	13.5	18.5	5.5
DIRECT PROJECT COSTS			
SALARIES AND WAGES	34.9	47	26
PURCHASES	15.8	29	7
SUB-TOTAL	50.7	60	38
INDIRECT COSTS			
SALARIES, WAGES, AND BENEFITS	26.7	30	22
PURCHASES	9.1	16	6.5
FIXED COSTS	13.5	18.5	5.7
SUB-TOTAL	49.3	60.2	39.5
TOTAL EXPENSE PER EMPLOYEE	$13,400	$18,800	$10,700

Fig. 9. Survey data for operating costs, 1956-57.

should be considered. However, there is no general agreement among laboratory managers as to the relation between organization structure, size, and the efficiency with which research objectives are achieved. As already stated, there are a multiplicity of successful ways of operating and no two laboratories are organized exactly alike. Therefore, there is no recognized relationship between organization structure and size.

In an industrial research laboratory, detached from business operations, there is a constant temptation to grow in size through increased work in areas of applied science, i.e., through encroachment on areas of work which should be done by operations components. Clear definition of the purpose and function of the research laboratory is necessary in order to avoid this temptation. It is equally essential that the purpose and functions of the operating components be defined.

FACILITIES OPERATION

Shop work in a laboratory doing experimental investigations includes work in metal, glass, ceramics, plastics, wood, etc. It involves constructing laboratory apparatus, instruments, and models ranging from rough to exceedingly fine, delicate work. It is frequently done from oral instructions and freehand sketches given by the scientist directly to the craftsman, and often develops as the work progresses. Research shop work requires skill, versatility, and temperament not usually needed in crafts workers.

The scientist usually needs the work immediately for continuity of his research, and on minor jobs he has the natural feeling that he could do it more satisfactorily himself. Will help of this kind for the scientist be better arranged if shop equipment and shop men are spread throughout the laboratory, or if they are concentrated in a central shop room? For economy in machines and men the central shop is advantageous, but simple tools and supplies should be on hand so that the scientist can "do it himself" when he wishes. It is advantageous to use outside shops for some portion of the work, in order to keep steady work and employment for the laboratory's own workers and to keep in touch with the methods and practices of others doing similar work.

MARKETING

The term "marketing" has a commercial ring, seemingly not appropriate to a research laboratory. However, research has end results which someone must buy.

These results must be delivered into the hands of those who can use them. The needs of the users must be collected and fed back into research planning; printed information must be prepared and distributed; relations must be maintained with others throughout the world of science; analysis must be made of application opportunities. All of this is essential for the support and effective application of research, whether in industry or elsewhere. The marketing function is too important in its own right to be done entirely by scientists incidental to their research. Therefore, men devoting their full time and attention to this work are essential.

PERSONNEL FUNCTION

THE WORK OF SCIENTISTS is professional work involving a high degree of self-direction and responsibility. Their positions are fixed in the organization structure, but with freedom to cross organizational lines to form technical teams or to work individually in other areas.

With respect to people in the other kinds of functional work in the laboratory, the first essential is to have the individual portions of the total work clearly spelled out so that every employee knows what his responsibilities and functions are. Each needs to know the part played by the others in his group and what the goals and strategies are. Coaching of the group and the individual members is as critical a factor as it is in competitive games. Scorekeeping is also essential, in order that the individuals will know how they and the group are doing. Scorekeeping needs to be cumulative, without any terminal points, although there will be transitions at points of promotions to better jobs. There must be opportunity for the individuals to learn and practice on their own, apart from the group, and to learn a new "game."

It is the responsibility of the personnel function to develop the system for doing these things, utilizing holeproof salary and wage plans, job descriptions, and appraisal procedures and other measurements. Inherent in the system should be strong incentives, i.e., tangible gains and recognition to be won by good work and teamwork. Job descriptions should include the challenge to enlarge and improve the job on the incumbent's initiative, rather than box him in and restrict his contribution.

Relations with employees individually, of course, are the responsibility of each manager individually. The personnel function is responsible for over-all employee, union, and community relations, wage and salary plans, health, safety, food services, etc.

Even in these brief remarks on the personnel function, the subject of communications requires mention. This is a means to integrate work and workers into a whole in the view of employees, as well as to give the employees an understanding of what goes on. There is no substitute for information addressed to employees individually, reaching them directly. Examples of this are letters to the employee at home commanding the wife's or husband's attention, meetings for all employees together, and information bulletins.

A system providing employees with opportunities for education, training, and self-development is, of course, a major responsibility.

FINANCIAL ADMINISTRATION

A COMPANY may pay for its research program, year by year, on a material, time, and overhead basis without accurate, detailed cost accounting. Furthermore, detailed financial planning and accurate cost estimating in advance may not be done. However, such lack of procedures makes effective expense control in the course of the work impossible and is unacceptable to many scientists. No one should have a stronger desire to get the most research for a dollar and no one knows how other than they. Furthermore, the cost of things exerts a powerful influence on the choices people make. Because all this is true, cost estimating, budgets, and sub-budgets, accounting to show true costs, direct charging, cost objectives, and expense control are functions necessary in a research laboratory. It may be assumed that if the scientist has regard for his own money, he will have regard for his company's money, and especially for the cost of research. However, cost estimating and accounting must not hinder creative work but, rather, should be designed to motivate it.

LEGAL OPERATION

KNOWLEDGE, when embodied in a specific application whose feasibility has been proved, has potential economic value. When original, it constitutes invention and is patentable. Patents, consequently, are a valuable end product of research work.

The legal function is uniquely important because breakthroughs in science set up series–parallel chains of application. Hence, the broadest of claims must be made, challenging the skill and perception of the attorney, and requiring him to dig deeply into the mind of the inventor. Moreover, the attorney must be qualified to help determine the key areas of science to unlock invention and to help determine research programs. Furthermore, the attorney should know the economic value of the patents he creates and should help evaluate the worth of research. Finally, he should evaluate results and offer critical yardsticks to help determine when to and when not to patent. He should also help to keep the scientists' minds focused on applications of knowledge without distracting their attention from its acquisition.

All this, in addition to the basic tasks of preparing, processing, and managing patents, makes the job of the attorney in research unusual.

WORTH OF RESEARCH

EVENTUAL WORTH OF RESEARCH from a business viewpoint lies in invention, i.e., in the embodiment of new knowledge in practical applications whose feasibility has been demonstrated. There are countless applications of new knowledge in the day-to-day improvement of

products and processes and in the solution of problems encountered in stretching technology.

In the case of patented inventions, a running appraisal of the value of patents is possible by assuming that the patents belong to someone else and estimating what one would be willing to pay to own the patents or manufacture under them. Alternatively, one can estimate what fee he would charge to license another, and then apply the fee to his own use of the patent. Although patents have disappeared from the assets listed in the balance sheets of many large corporations, there has been enough practical experience in evaluating them and in licensing to make their value one factor in appraising the results of research. Moreover, such information helps to determine appropriate practice for filing applications for patents.

Use of a patent to improve a product, which in turn improves other products or systems, creates chains of improvements, all stemming from one patent. The value of a patent is usually calculated on the basis of the value of the improvement of the first product alone. Therefore, valuation of patents is a partial valuation in a company whose product scope is broad enough to encompass the subsequent improvements.

It is, of course, impossible to evaluate the worth of the many day-by-day uses of advanced knowledge when such knowledge is steadily fed to creative people in the business operations. This is an extremely important result of research.

In the case of specific applications of such importance as to lead to new investment in plant and equipment, it is routine to calculate the recovery and profits expected. Sometimes these applications are clean, i.e., a breakthrough in science creates wholly new products. More often, the application is one of many factors involved in the development of a product, making it difficult to isolate and evaluate the value. As in the case of patents, the application to practice sets up chains of benefits. Hence, evaluation of the primary ones gives only a partial measure of worth. However, such information, even though partial, casts light on the worth of research and on the relative value of undertaking proposed research projects.

HOW MUCH RESEARCH?

ONE APPROACH to the question of how much research should be undertaken is to recognize that the work of a laboratory is (1) to determine key areas of science to unlock new business opportunities, (2) to analyze progress of science and likelihood of breakthroughs in key areas, (3) to do research in key areas, and (4) to feed new knowledge and invention to business operations. How much to spend on research, then, depends on the number of key areas, the selection of projects in each area (with consideration being given to the work being done elsewhere in the world of science), and the manpower and facilities required by each project.

Expressed differently, the approach is to recognize that the research laboratory is coupled to the business operations of the company through the intake of information on their technical needs and the output of information on new business opportunities. Technical needs are translated into needs for knowledge and understanding in basic science areas. Possible business opportunities are visualized in terms of new products and processes with new properties and capabilities. Then the research program is designed in each science area to produce the knowledge for the application in view. In fact, when research projects are expressed in terms of (1) technical needs, (2) research work, and (3) possible applications (business opportunities), they can be appraised with some confidence. Some of the opportunities are long-range, of course, and are dimly visualized in the sense that unrecognized opportunities will be discovered, as past experience has shown.

This approach is in harmony with the freedom of individual scientists to pursue research according to their own interests. Curiosity and a thirst to understand natural phenomena for its own sake are impelling characteristics of a scientist. But he wants to participate in advancing scientific knowledge and to fit his discoveries with those of others, so that progress can be made as the sum of many contributions. It is a safe bet that he is confident of practical uses of new knowledge. For example, when he creates and studies materials of unusual atomic or molecular structure, or of unusual purity, he is confident something new of practical use will result. He is engaged in a quest for the secrets of nature to unlock the doors to new practical benefits. This personal approach is not in discord with the approach stated in the preceding two paragraphs. Furthermore, when the scientist is employed in the first place because his interests and those of the company coincide, and when the company is large and diversified enough to provide a vehicle to put almost any discovery to practical use promptly, his work is both guided and stimulated.

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Wear Your ◆ AIEE Badge

Lightning Performance of 138-Kv Double Circuit Lines

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THE COMMONWEALTH Edison Company operates a 138-kv and a 230-kv overhead transmission system in northern Illinois. Prior to 1954, most of the 138-kv circuits were carried on double circuit steel towers designed for two overhead ground wires. A typical 138-kv tower is shown as type A in Fig. 1. This tower has given very good lightning performance based on cumulative 6,351 year-miles of experience with circuits on towers where both circuits and both ground wires were installed, and 3,782 cumulative year-miles where only one circuit and one ground wire were installed. However, the type A tower had not given satisfactory service with respect to flashovers caused by galloping conductors under ice and wind conditions; for this reason, the type C tower in Fig. 1 was developed.

Notwithstanding the excellent lightning performance of the type A tower operated with only one circuit and one ground wire, and the favorable design performance predicted from the AIEE Committee Report (AIEE *Transactions*, vol. 69, pt II, 1950, pp. 1187-96), the type C tower produced a very poor lightning performance record shortly after initial installation and has had an average trip-out rate during a 3-year period considerably in excess of all expectations. Field investigations demonstrated that the 30 degree shielding angle was properly protecting the phase wire.

An analytical study was made to determine how the original type C tower might be modified by the addition of a second ground wire to give better lightning performance.

Modification of the type C tower by the addition of a second ground wire in a horizontal plane at the same elevation as the original ground wire increases the magnetic coupling factor K of all phases by approximately 50% and produces a reduction in the ground wire surge impedance Z. This modification also reduces the induced voltage E caused by indirect strokes.

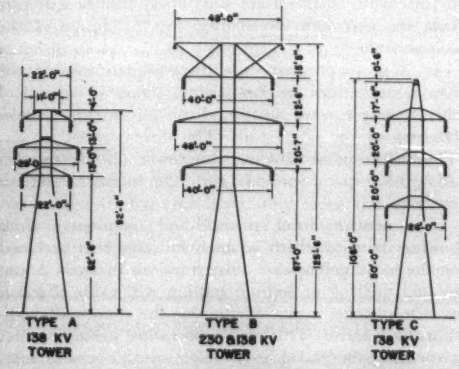

Fig. 1. Outline dimensions of double circuit towers.

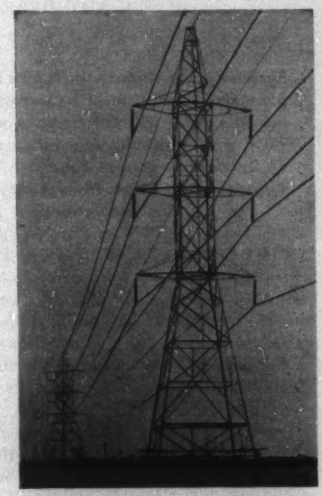

Fig. 2. Photograph of towers with two ground wires in a vertical plane.

Locating the second ground wire at elevations directly below the original ground wire improves K and E for all phases even more than the horizontal modification. A location of 10.75 feet below the top conductor arm was found to provide the best balance of K and E for all phases consistent with tower strength requirements and clearances for galloping conductors. It gives a better K for the top and middle phases than the values of the type A and B towers. The Z is lower for this design than for the A, B, and horizontally modified C. As shown in Fig. 2, a second ground wire was installed in a vertical plane on an existing type C tower line (24 miles long).

The Commonwealth Edison Company now has a field laboratory of type A, B, unmodified C, horizontally modified C (15 feet and 26 feet ground wire separation), and vertically modified C towers. Lightning performance of these various designs during the years to come will provide valuable data for designing towers in the future.

Digest of paper 58-14, "Analytical Studies of Lightning Performance of One and Two Ground Wire 138-kv Double Circuit Lines of the Commonwealth Edison Company," recommended by the AIEE Transmission and Distribution Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Feb. 2-7, 1958. Published in AIEE *Power Apparatus and Systems*, June, 1958.

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Design Considerations in a Nuclear Safety Instrumentation System

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Because of the characteristics of a nuclear power plant, much effort must be expended to insure that the plant will not create a public hazard. Thus, the safety instrumentation system is one of its most important features. The proposed system for the Enrico Fermi Atomic Power Plant is described.

THE CONCEPTUAL DESIGN of the nuclear safety instrumentation system for a central station nuclear power plant provides considerable insight into the complexity of the instrumentation requirements for such a system. The proposed safety instrumentation system for the Enrico Fermi Atomic Power Plant, located on Lake Erie near Detroit, Mich., is used as an illustration of this complexity.

The formulation of a basic approach to the nuclear safety instrumentation system for the Enrico Fermi plant is of prime importance. It is intended that the systems presented in this discussion will give a clear idea of some of the nuclear instrumentation problems associated with this reactor.

The fundamental concepts as presented are peculiar in some respects to the fast breeder power reactor and, in particular, to the problems and needs of the Enrico Fermi plant. These concepts take cognizance of the ground rules that have been established for the nuclear as well as non-nuclear portions of the plant. The results of various control and safety studies now under way may alter certain aspects of the approach. However, it is felt that the basic approach will still apply.

FUNDAMENTAL CONCEPTS

THE CHARACTERISTICS of a nuclear power plant are such that much effort must be expended to insure that the plant will not create a public hazard. The reactor must be designed in such a manner that safety to the public is insured even in the event that all safety and control systems fail. The concepts required to obtain this safety will not be covered in this discussion, inasmuch as they are not primarily concerned with the instrumentation.

Essentially full text of a paper presented at the 3rd Nuclear Science and Engineering Conference, Chicago, Ill., Mar. 17-21, 1958. Recommended for publication by the AIEE Nucleonic and Radiation Instrumentation Committee.

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The fundamental reasons for the existence of the safety portion of the over-all instrumentation system are as follows:

1. To prevent fuel melting.
2. To prevent sodium boiling.
3. To prevent damage to the reactor and plant components.
4. To reduce the severity of an abnormal condition or accident.

The unusual problems of remote handling of many plant components which may be radioactive, and possible extensive clean-up problems, make it imperative that measures be taken to provide component protection. The clean-up problems are chemical as well as nuclear in nature, since the sodium itself makes the problem of handling somewhat difficult. From the economic aspects alone, component protection is important. Therefore, a major role for the safety system is component protection.

The safety system is not intended to be capable of stopping all conceivable accidents. Rather, in nearly all cases the action initiated by the system will reduce the severity of the abnormal condition, thus providing some measure of protection. The safety system must be capable of stopping the start-up accident, i.e., that accident in which all poison rods are removed from the reactor at their maximum rate until all available reactivity is inserted and all shutdown means have failed, except the primary safety circuitry and shutdown mechanisms. A fast mechanical system coupled with adequate electronic response time is necessary to accomplish this requirement. Appropriate simulation studies will provide the necessary information for the design of the components.

It is proposed that only three signals initiate the scram mechanism of the reactor. Scram is defined as the fastest means of shutting down the reactor, i.e., delatching of the safety rods. The three signals are (1) The highest permissible neutron level; (2) The shortest allowable reactor period; and (3) Incipient sodium boiling.

The neutron level, period, and incipient sodium boiling point at which scram is initiated will be based on the requirement that only situations that could lead to fuel melting or sodium boiling will cause a scram or that all other means of stopping the abnormal conditions have failed. This may seem rather strange at first glance, but thermal shock problems in this reactor leads one to accept such a philosophy.

As in most reactors, a number of operational modes can be utilized to control the reactor under normal and abnormal situations. It is imperative that these operational modes act independently of one another. Even if corrective action under one method of operation is taking place, another method must still be capable of performing its normal task, i.e., scram during a fast rundown of the safety rods.

The need for the utmost in reliability is of prime importance. The desirability of staying on the line, imposed by the electric power plant, requires a new approach to the over-all instrumentation system. Many of the system components must function under unusual environmental conditions for as long as 10 years. Some components must operate for this period without the benefits of routine maintenance and calibration. This is beyond the operational experience of many of the components presently available. It is safe to say that a new standard of reliability must be set when instrumentation for a nuclear power plant is desired.

Although it is difficult to obtain the desired reliability under the severe operational conditions, reliability is of prime concern and is an integral part of the safety control philosophy. By way of illustration, the safety system must operate when called upon on those rare occasions when it is needed, yet it must not cause spurious shutdowns over extremely long periods of operation. This must be accomplished without extreme preventive maintenance or the use of highly trained personnel for routine or special maintenance.

The problems associated with thermal shock are serious. The wide band of uncertainty existing when an attempt is made to evaluate the ability of complicated components to withstand thermal shock is understandable. With this in mind one leans to a conservative approach to the nuclear instrumentation system, inasmuch as the reliability criteria become severe. It is apparent that the total number of scrams must be strictly limited. Therefore, scrams resulting from instrument failure cannot be tolerated. This is contrary to current practice in research reactors, where an instrument failure may shut down the reactor with only inconvenience as a result.

In light of the thermal shock problem, the corrective action initiated will be dependent upon the severity of the abnormal condition. If one mode of corrective action does not alleviate the abnormal condition or if it increases in severity, a more drastic corrective action is called into operation. It can be said, in general, that a more severe shutdown mode is initiated if the abnormal condition could lead to a more drastic situation than that caused by the shutdown itself from the thermal shock viewpoint. The ability to initiate shutdown action independently, dictated by the severity of the situation, leads to the fundamental requirement of safety in depth.

PROPOSED INSTRUMENTATION SYSTEM

Safety and Control Rods. It is presently planned to operate all safety rods as a unit (ganged) at a minimum safe rate to be determined from simulation and other studies. The present design concepts dictate that the final position of the safety rods is located at the top of the axial blanket. It has been suggested that location of these rods at the core-blanket interface would reduce the effective delay in scram time to a minimum. Present thinking indicates a total scram delay of 50 milliseconds for the mechanical delatching and 5 milliseconds delay in the electronics, if the safety rods are positioned during operating at this interface.

The two regulating control rods will be of equal worth, having a total reactivity of 92 cents.* It is possible that after initial operation this may be changed. However, it should be pointed out that the control and safety studies will dictate the control rod parameters.

As indicated previously, the shutdown mechanisms in the Enrico Fermi reactor can be actuated independently, and the mechanism utilized is dependent upon the severity of the abnormal condition. With this concept of safety in depth, there are five means by which safety action can be initiated. The following are these mechanisms in order of increasing severity:

1. *Alarm.* Alarm indication to permit the operator to detect and correct an accident within narrow limits.

2. *Stop All Rod Motion.* The negative temperature coefficient is sufficient to handle certain situations, provided additional complications are not introduced by rod motion. This action is initiated when certain limits are exceeded either manually or by the automatic control systems, i.e., if the operator is withdrawing the rods, their motion is stopped independently of operator action when an abnormal condition exists.

3. *Slow Rundown.* This mode incorporates re-insertion of the control and safety rods, or all rods at their normal speed of operation. If certain limits are exceeded and previous corrective action fails to stop the abnormal condition, the rods are automatically re-inserted into the reactor at their normal rate of 1 cent per second. Two types of setback are included: (a) Setback until abnormal condition is relieved, and (b) Setback to a predetermined lower level of operation.

4. *Fast Rundown.* A controlled dropping of the safety rods at a faster rate than normal takes place due to operation of a release mechanism in the drive unit. Under this mode of operation, the rods are not delatched from the drive racks. The rate of this action is to be designed to approximate the decay curve of the primary coolant pumps.

5. *Scram.* This mode is the fastest possible means of shutting down the reactor. The safety rods are automatically delatched from the drive rods and accelerated by means of springs. The total time to insert the rods fully is approximately ½ second.

Start-Up Channels. An auctioneering-type system (Fig. 1), in which any one of at least two operating channels can independently initiate corrective action,

* In reactor engineering, "dollar" is used as a term for the difference between the reactivities for a given reactor corresponding to the delayed critical and prompt critical conditions, and 1/100 dollar is called a cent.

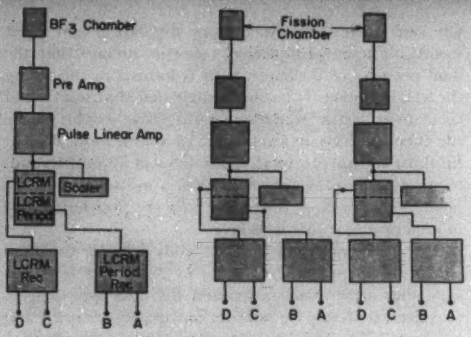

Fig. 1. Counting range channels.

A—Period: P_1, P_2, P_3 *C—Source monitor*
B—Period limit on chamber retraction (to rod stop) *D—Chamber retraction*

is proposed for both the BF_3 and fission chamber counting channels. It is felt that this approach satisfies the safety needs in the counting range of the start-up phase of plant operation. It is during this phase that accidents are most likely to occur. The auctioneering philosophy is adaptable to the reactor in this range because there is no significant heat production in the counting range. Thus, the thermal shock problems are nonexistent. The instrumentation system is more susceptible to instrument failure using this philosophy (auctioneering), but the infrequent shutdowns can be tolerated in this range. The economy of equipment and resultant lower maintenance of the complicated pulse equipment, coupled with added confidence in the ability to stop abnormal conditions, warrants the auctioneering approach.

It should be noted that log count rate period information is proposed. The ability to obtain anticipatory information at a low power level is of extreme importance. Techniques are available today to obtain this information reliably. Although the reactor will be operated manually during the initial operational period, the availability of this count rate period signal makes it possible to adopt a completely automatic reactor start-up system. The automatic start-up feature may be desirable because it frees the operator from routine tasks. Therefore, he is in a better position to observe over-all reactor operation during the critical period. The ability of the operator to make a decision and take action during a period when multiple abnormal conditions are occurring is a significant safety feature.

The various limiting actions and interlocks for these channels are indicated in Fig. 1. These are by no means complete, but they are fundamental to the safety approach.

1. A count rate period action which will initiate certain limiting conditions on the reactor when the rate of change of power level exceeds preset limits. Three different period groups can be defined:

P_1—a reactor period which stops rod motion. The safety rods are stopped if they are not fully withdrawn. If the safety rods are fully withdrawn the control rods are stopped. An 80-second period might be considered representative.

P_2—a period which initiates slow rundown of the rods. In certain conditions only the safety or control rods might be inserted. A 50-second period would be representative.

P_3—a period that would initiate a fast rundown. A 15-second period would be representative.

2. A limit on safety or control rods (or both) such that the reactor is on a very long period before the chamber is retracted. This situation is applicable only if range extension by chamber retraction is required.

3. A limit which forbids safety or control rod withdrawal until a minimum count is detected. This is a source monitor.

These periods and levels are not final by any means, but are presented for illustrative purposes only. It will be one of the primary aims of the safety studies to determine these parameters.

The radiation detectors are housed in vertical tubes about 6 inches in diameter located about a semicircle in the area between the reactor vessel and the primary shield tank.

Three compensated ion chambers supply neutron information for the linear power level servo control system. The symmetry of detector locations about the reactor core is required to insure that reasonably similar reactor information is supplied to the auctioneering and coincidence circuits. If this is not done and the differences are sufficiently great, the auctioneering and coincidence approach is invalid. The BF_3 and fission chambers are located nearest to the reactor core. At the present time, it is felt that for initial start-up the BF_3 chambers can be installed temporarily until the source strength is increased and sufficient information is obtained. The other option is to install the BF_3 chambers in place of the fission chambers during initial operation. Probably the first approach is best from the performance information standpoint.

The flux levels at 300 mw, available at the various detector locations, are shown in Fig. 2. The flux available at start-up is dependent upon the source strength and the reactor history, but is somewhere between 10^{-8} to 10^{-11} of the flux level indicated for the start-up detectors in this figure. A minimum value of 10 thermal neutrons per square centimeter per second is desired at the start-up detector locations. Studies are now underway to verify the source flux levels at the instrument locations.

The possibility of a need for wider range operation in the pulse-counting range can be accommodated by alternate chamber positions. If greater than four decades are required before information is available in the logarithmic instrumentation channels, the chambers can then be positioned to an intermediate point and con-

tinue to supply the needed information. Several important interrelated operations must be accommodated:

1. When the count rate approaches the capabilities of the instrumentation and before the chamber is retracted, all rod motion must be stopped.

2. The detectors must be located such that information is available from an alternate channel during repositioning of the detector. An overlap of one decade of operation should be sufficient.

Logarithmic Channels. A coincidence approach in which at least two of three or more channels must indicate an abnormal condition before corrective action can be initiated is utilized in the logarithmic and power level instrumentation channels (Fig. 3). This approach insures a minimum number of accidental shutdowns because of instrument malfunction.

Four identical channels are proposed. When all four channels are operating, two out of the four channels must indicate an abnormal condition before action is initiated. When only three channels are operating, two out of the three channels are required to indicate an abnormal situation before a shutdown is initiated. If only two channels are operating, the reactor cannot be started or it is shut down if in operation. The shutdown action will be slow rundown, since fast rundown and scram actions are available for back-up. Four channels are utilized for the following reasons:

1. Instrumentation can be replaced during reactor operation without shutting down the reactor.

2. Coincidence is maintained, even though one channel is removed for replacement or is not operating. The implication is that a considerable length of time is available for trouble-shooting without jeopardizing the reactor should subsequent instrument failure occur.

3. Although one can design the instrumentation for quick replacement in a channel, a certain amount of time is required for warm-up and calibration.

4. If an automatic checking scheme is utilized, coincidence can still be maintained while the one channel is undergoing the checking operation.

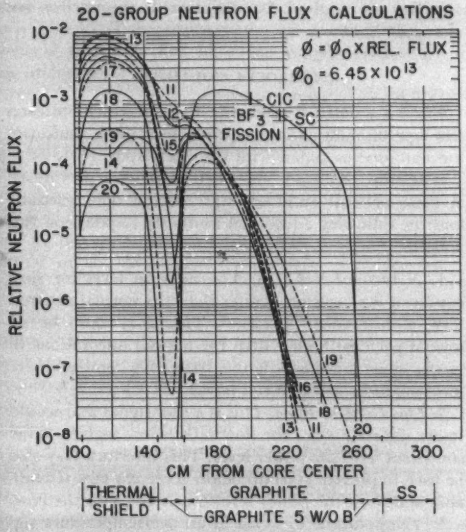

Fig. 2. Neutron distribution in primary shield and detector locations.

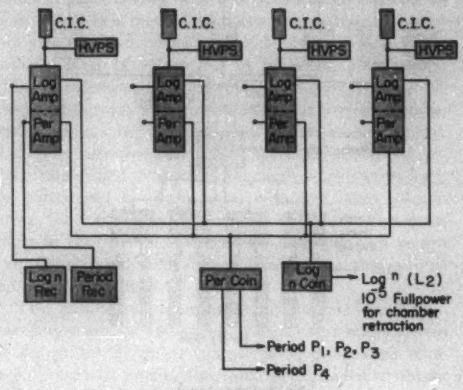

Fig. 3. Power range channels.

In the logarithmic instrumentation, two additional shutdown signals are utilized beyond those previously indicated:

1. P_4—The period signal that initiates a scram.
2. L_2—A neutron level which actuates the fast rundown mechanism.

Level Safety Channels. The coincidence philosophy is utilized in the level safety channels as well as in the logarithmic channels (Fig. 4). A neutron-level signal L_1 actuates the scram mechanisms of the safety rods. The level at which this scram is initiated must be based on the accident which the safety system must stop, that is, the start-up accident. Because of thermal shock problems, the number of times the reactor can be scrammed is seriously limited. Therefore, much effort must be concentrated on obtaining reliable instrumentation. The level safety system operates on the 2-out-of-4 or 2-out-of-3 coincidence scheme described earlier. The level L_1 must be determined in a simulation study because of the complexity of the problem. The following factors enter into the study:

1. Mechanical delay in the delatching operation of the safety rods. Present specifications call for less than 50 milliseconds.

2. Travel time of the safety rods before effective reactivity is inserted into the core. This time should be minimized.

3. Electronic delay, the time delay encountered from the time an abnormal condition occurs until the appro-

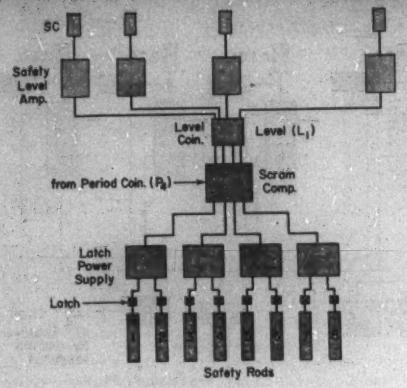

Fig. 4. Safety circuit.

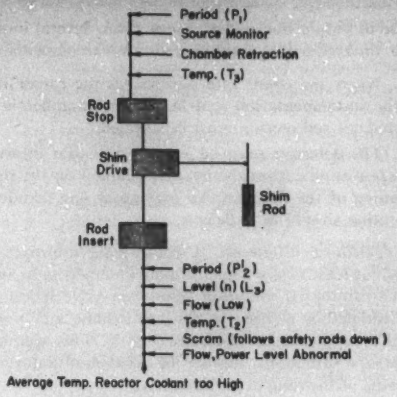

Fig. 6. Shim rod circuit details.

priate electric signal is received at the latch, must be kept as short as possible consistent with reliability. A delay time of 5 milliseconds is realistic.

4. The dynamic characteristics of the reactor.
5. The maximum rate of insertion of reactivity.

The detectors indicated in Fig. 4 as SC or safety chambers could be of several types, dependent upon the environment. Uncompensated ion chambers could be utilized. However, the severe gamma problem caused by stainless steel gammas from the structural material may require compensated chambers.

The safety level amplifiers may be of several types, dependent on the necessary response time and reliability requirements. Sixty-cycle magnetic amplifiers are probably too slow to be consistent with the safety requirements. Electronic circuits utilizing vacuum tubes are probably less reliable. Electronic circuits using solid-state devices may provide the best instrumentation. In the case of the magnetic devices, they probably should be operated at frequencies of 800 to 1,000 cycles in order to achieve proper response times. The level coincidence circuits and the scram comparator should utilize the same techniques.

The latch power supply is really two magnet supplies with diode isolation. Each magnet supply is capable of supplying current for two latch magnets. In normal operation the two magnet supplies share the load. If one supply fails the other magnet supply carries the full two-magnet load. Thus, a magnet supply can be removed and replaced during plant operation without initiating a shutdown. Because of detailed instrument problems, a latch supply for each safety rod may be desirable. Each magnet supply must then be capable of supplying current for one magnet. Thus 16 magnet supplies are required, but the over-all approach is not changed.

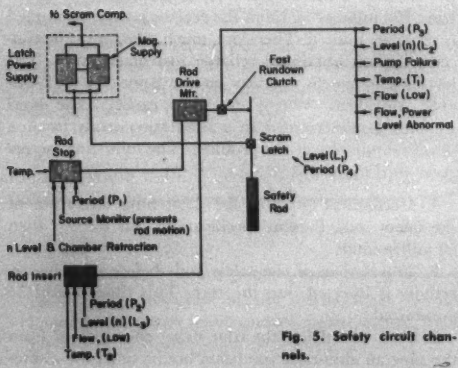

Fig. 5. Safety circuit channels.

INTERLOCKS AND LIMITS

FIG. 5 is a detailed schematic diagram which indicates the type of information required to initiate shutdown mechanisms associated with the safety rods.

The stop rod mode has been explained previously. Reverse or slow rundown was covered only partially and the following additional limits are imposed on this action:

1. *Neutron Level* (L_s). The neutron level for slow rundown is somewhat greater than the normal neutron level at full-power operation. This level could be set several per cent higher than the normal fluctuations in power plus the noise of the system. A representative level might be 110% of full power.

2. *Low Coolant Flow*. This is a flow signal that would insert the rods when the flow falls below a given value consistent with the power level. This interlock may also be used to prevent start-up before a certain flow is available and limit the power level consistent with the flow.

3. *Temperature* T_s. This in an overtemperature signal for slow rundown, and is above the normal operating

temperature. The rods would probably be run down until the temperature is restored to normal.

The fast rundown mode is initiated in a similar manner to that stated previously, only the situations are more severe. Fast rundown is the fastest shutdown mechanism initiated by a temperature signal except for sodium boiling indication. Preliminary simulation studies indicate that even with the slow response time of temperature devices, certain types of accidents can be overcome with a temperature signal. An average coolant temperature of 1200 to 1300 F is representative of T_1. The flow power level abnormal signal is a very important interlock or shutdown signal. It requires that the power level be consistent with coolant flow, or, if it is not, a shutdown is demanded.

Fig. 6 is a detailed schematic diagram indicating typical signals which initiate the various shim rod modes. Inasmuch as the shim rods are most effective in the range from criticality to full power, in situations when the abnormal conditions are not so severe that the safety rods have to be called into play, the shim rods are actuated independently. As an example, a reactor period can be found where shim rod action alone can correct the abnormal conditions. As an additional safety feature, the shim rods may be inserted when a scram or fast rundown is initiated. After a scram, the drive units for the safety rods are run down to insure that the safety rods are fully inserted into the core.

CONCLUSION

THE SAFETY-IN-DEPTH PHILOSOPHY is evident in the preceding discussion. The interplay of the various limits and control functions is, perhaps, not quite so obvious. This interplay is an important part of the over-all safety approach and is a very important back-up on instrument failures if the instrumentation system design is properly executed. The following examples illustrate this interplay:

1. If the flow power level abnormal signal fails to function properly, the reactor coolant temperature signals will prevent damage to the reactor. If, in turn, the temperature signal fails, the reactor coolant temperature differential signals can initiate a shutdown.
2. If the coolant pump failure signal fails to actuate the fast rundown mechanism, the flow power level abnormal or the overtemperature signals back up the system.

The proper design aspects are important. For instance, the detectors and the associated equipment for measuring the reactor coolant temperatures should be independent of the temperature differential instrumentation.

A concentrated simulation study will indicate the limits of the parameters that are of importance from the safety standpoint. The simulation study must take into consideration the response times associated with the detectors for the various parameters as well as the response times of the associated equipment. In conjunction with the determination of these limits, the delay times of the limiting or shutdown mechanism must be considered. It is recognized that a simulation study cannot give absolute values for the parameter limits. However, a range of values can be obtained. Fortunately, this is consistent with the flexibility requirements of the instrumentation. The normal control range instrumentation has not been included in this discussion because a definite mode of control for this reactor has not yet been established. Naturally the control parameters must be considered in conjunction with the safety parameters. The interplay of control and safety functions must be considered. However, the final detailed design can be accomplished rather easily when the control mode is determined.

The reliability requirements of the nuclear instrumentation are very stringent. The nuclear safety system is the prime safeguard against plant component damage. Therefore, much effort must be expended to obtain reliable components as well as reliable system. As stated earlier, it is felt that solid-state devices should be used where they are applicable.

Intimately associated with the reliability requirements is the scheme for monitoring the nuclear system performance. An adequate monitoring system not only must be capable of performing static checks, but also, and more importantly, must evaluate the dynamic performance of the system. Ideally, the monitoring system should check the system from the neutron-detecting device up to and including the limiting or shutdown device. This idealized system can be approached in several ways. It is felt that a dynamic check which includes the detector and checks the system performance by simulated signals nearly identical to the actual signal levels is necessary. As an example, if a movable neutron-absorbing shutter surrounding the detector were rotated, a high neutron level signal could be simulated. This can be used to check individual instrumentation channels. Since a coincidence type system is proposed for this plant, a check of the coincidence network is also necessary in order that the monitoring system be complete.

Automatic Riveters

Four new numerically controlled riveters at Boeing Airplane Company's Wichita, Kans., plant are now being used to build wing panels for the *B-52* Stratofortress. All four machines are controlled by signals on punched tapes.

Each machine automatically drills and countersinks the hole, inserts a rivet slug, upsets both ends, shaves off the outer head, and then moves on to the next rivet. Eight to 10 rivets per minute are driven, fastening stiffeners to lower wing panels. The new riveters are about 12 feet high and 10 feet wide and roll back and forth over the work on floor rails. Wing panels as big as 75 feet in length and 4 feet in width can be riveted.

Special Electric Systems on Aircraft Carriers

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SINCE THE INTRODUCTION of aircraft carriers to the fleet of the U. S. Navy, their role has continually increased in scope as well as in importance. This has been chiefly caused by advances made in aircraft and associated weapons and systems. This discussion will be limited to cover only certain special power and lighting systems which are considered to be broad enough in scope to be treated individually.

Aircraft Starting and Servicing. For starting a jet aircraft, approximately 33 kw of low-voltage d-c power is required. This power must be limited currentwise to produce "soft starts." This control prevents development of excessive torques that would damage the motor or mechanical coupling between the motor and jet engine.

Servicing power is required for at least three purposes:

1. It is required at combat-readiness stations to supply continuous power to interceptor aircraft for keeping the aircraft's electronic gear and other vital equipment in a warmed-up "ready" condition.

2. It is also required at almost any location on the flight deck for routine warm-up and check-out of the aircraft's gear just before take-off.

3. It is also required on the flight and hangar decks and in aviation shops for routine test and maintenance.

Night Flight Lighting System. These systems provide the pilot making the landing approach with orientation information under adverse weather conditions and at night. They each consist of a number of high-intensity lights arranged so that the runway edges, the runway center-line, the stern ramp, and the bows are depicted. To obtain more nearly a point source for better light control and for better high-shock characteristics, low-voltage lamps (6 volts) are utilized. Each is fed from its own step-down transformer. Because visibility varies a great deal with different climatic conditions, it has been found necessary to provide intensity control for each of these systems of lights by the use of magnetic amplifiers to control the input to the transformers.

Optical Glide-Path Indicator System. This system gives the incoming pilot an accurate visual indication of the glide-path angle of the aircraft during the descent. In the past, this function was accomplished by a landing signal officer who relayed this information to the incoming pilot with arm signals.

The principle of the presently used system is based on viewing the reflections of a light source in a mirror and comparing the apparent vertical location of the image with datum lights located on each side of the mirror. When the pilot sees that the image is lined up with the datum lights, he knows that he is on the proper glide path. The mirror system is used most advantageously during inclement weather. However, inclement weather is usually accompanied by rough seas, which cause the ship to roll and pitch. To compensate for this movement, the mirror is stabilized in a one-axis system. This system uses the ship's gyro compass for its source of roll-and-pitch signals and the mirror automatically adjusts itself to the ship's motions, thus presenting a true glide-angle indication at all times.

Hangar Deck Lighting Control. The hangar deck on a carrier is the main deck and is divided into two or three large bays separated from each other by very large light-tight sliding doors. Each bay opens up to an elevator platform also through very large light-tight doors.

By means of selector switches and door switches, the illumination of the hangar bays can be controlled in a number of ways. Under darkened ship conditions, the selector switch can be set so that the white or red illumination will stay energized as long as none of the side doors are opened.

In addition to night vision adaptability, red illumination is used, depending on certain conditions in connection with darkened ship security. That is, the red lighting fixtures are so located that they are not directly exposed to the weather. Consequently, by the setting of a selector switch, the door switch control can be set up so that the white lights will remain energized until a door is opened, at which point the white lights will go out and the red lights will go on.

Guided Missile System. The latest aircraft carriers under construction are being provided with guided missile capabilities. From an electrical viewpoint this involves supplyling power for missile guidance systems, missile check-out, and missile launching. Most of these systems require very nearly transient-free power closely regulated in voltage and frequency, and at voltages and frequencies other than that of the ship's basic generating plant. At present, most of these loads are supplied by motor-generator sets. However, it is hoped that with the development of suitable line regulators and electric speed governors, the large number of small motor-generators can be replaced with a few large centrally located motor-generators to supply the system.

The number and variety of loads associated with aircraft carrier operation is continually increasing, creating new problems, most of which can be solved locally. However, problems that can and do affect the whole electric system must be given careful consideration with a view toward any major change in electric plant philosophy required for future ship installations.

Digest of paper 58-567, "Special Power and Lighting Systems on Aircraft Carriers," recommended by the AIEE Marine Transportation Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Middle Eastern District Meeting, Washington, D. C., Apr. 28-30, 1958. Scheduled for publication in AIEE *Applications and Industry*, 1958.

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Motivation and Human Factors in Engineering Leadership

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The study of the human relations aspects of the engineering manager's job may well be as important as the technical and economic problems he faces. The concepts of motivation and recognition, as applied to the field of engineering, are explained and discussed.

TO THOSE interested in engineering management and leadership it is encouraging that, under the sponsorship of management committees, the real problems are now being discussed. The problems of human relations and of motivation as applied to engineering have not been widely explored, and it is hoped that this article may stimulate others to discuss their experiences and ideas, for certainly there is much yet to be learned in this field.

The thoughts presented here are based on 30 years of interested observations crystallized by the experience of organizing and conducting discussion-type classes on human relations for engineers, *(Electrical Engineering,* July 1958, pp. 586-88) and more recently from seminars held with some of Westinghouse's most creative engineers at East Pittsburgh, Pa., delving into the background and the motivation for their more important creative ideas. The results of this seminar were discussed with many engineering managers and they, in turn, had suggestions of how they could help provide the motivation for creative work.

The manager or leader of a group of engineers must have something more than just technical knowledge and proficiency, although these factors do help to command respect, which is a necessary element of leadership. The leader of any group must understand his people and must know how to deal with all types of people. It is in this area of motivation and human relations that many of us need to give considerable thought, if we are going to lead engineers to make the most of their potential abilities. While there may be nothing new in the concepts presented here, it is hoped that they will be tested against your own experiences and, if found to be sound, that they will be used as a basis for action and for further study.

BASIC DRIVES AND MOTIVATION OF ENGINEERS

ENGINEERS are, first of all, human beings with all the basic drives and emotions of other people. The physical needs and comforts are basic drives but, as Dr. Douglas Brown of the Massachusetts Institute of Technology points out, once these needs are well satisfied they cease to be strong motivation. With people on a high standard of living, even the desire for security is based more on the social need of maintaining position than on security from actual want. The engineer, being generally individualistic, does not always realize the power of man's social needs. The need to belong to and to feel accepted by a certain group is very real, even among engineers. With some, this takes the form of wanting to belong to a certain social group; with engineers, it is more common to want to be accepted by their fellows in their chosen field of activity, or they may want to be part of the team working on a certain line of apparatus or a certain project.

Every man has his own picture of where he stands in the minds of those whose respect he values, frequently referred to as his status. He will strive to maintain his status and often is insulted if anyone fails to recognize it. If we do anything to tear down a man's stature, he is depressed or he is resentful. If we can sincerely build him up, he is encouraged and motivated.

Ideals and principles are strong motivations. Just as a man carries a picture of his own status or importance, he also pictures himself as a man with certain ideals and loyalties, and, again, he may resent any implication that he is not what he believes himself to be. The ideal of honesty and that less common virtue of intellectual honesty are generally strong factors in the behavior of engineers and should be understood and appreciated by management.

In the series of seminars referred to previously, we delved rather deeply into the motivation for creative work. The observations from these collective experiences are worth noting. It was an almost universal experience of these men that their good ideas came only after periods of sustained conscious thought and analysis, frequently including experimentation. However, it was also a common experience that their best solutions seemed to come to them from their subconscious at times when their minds were apparently idle; while walking to and from the laboratories, driving to work, doing manual tasks, and even while shaving or taking a bath.

Many in the past, including the mathematician Poincare, have pointed out this type of experience, but the author was impressed by the implications of it and by the further observations of this group of engi-

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neers. To sustain the necessary conscious mental effort and to keep one's subconscious working most certainly require a very strong desire to accomplish something. What are the chief motivations that supply the drive of such people? Many of these men stated in the class or in private discussions that their strongest motivation was the desire for recognition. They wanted recognition of their work from management or some technical leader, and they wanted recognition and acceptance by their fellows in the same field. Both were important.

Another important element in their creative work was confidence that they would succeed. Many times this was said to have been inspired by the enthusiasm and expressed confidence of their leaders. Cases were mentioned where an engineer identified himself so completely with a line of apparatus that any observation or suggestion, however remote, was analyzed consciously or unconsciously to see whether it could contribute to the special problems of his line.

It was recognized that engineers vary widely in their apparent creative ability. Thus, it is important to know how to detect creative ability. The problem of testing for creativity will not be discussed here, but it is interesting to explore the reasons that certain people have a strong natural drive for creative effort. Some of these men traced their bent for invention and problem-solving back to childhood experiences where they gained recognition or attention by their ideas.

This brings up the question of whether some engineers are driven to creative work only as a means of self-expression, as artists and writers are said to be. The author leans to the theory that some appear to have this built-in urge to create, but that it probably was inspired by some early recognition. Most important, though, is that whatever the cause of this built-in motivation in a young engineer, its future development on the job can be greatly influenced by the encouragement, enthusiasm, and recognition given him by his leader and those around him.

Concerning the need for recognition by their fellows, this group of creative engineers stressed the desire such people have to tell others of their work. If any of you have ever attended a physicists' convention, you may have received the impression that their one objective was to tell everything they knew. Most engineers get recognition in other ways, so the desire to talk about their work is not all-powerful; yet they also appreciate the chance to tell of their work. If their leaders provide them with the opportunity to talk, there is a double motivation—they are shown recognition by the leaders and gain attention from their fellows.

The manager should recognize that the more creative engineers may have some traits in common with artists and other creative professionals. The creative and imaginative mind must have a freedom and a willingness to question and examine all the rules and conventions. This habit of disregarding convention at times carries over into areas where it may embarrass the manager. Eccentricities do not guarantee creativeness, but they do sometimes go with it.

Another characteristic of many creative people is a dissatisfaction with things they consider inefficient or imperfect. Many critical people are not creative, but again many creative people feel these dissatisfactions. As long as they are striving to improve things by their own efforts, we should be reasonably tolerant of and understand their dissatisfaction, and help them to evaluate what can the done within economic and other limitations.

HUMAN RELATIONS

We must not depend too much upon generalizations about motivation or upon an involved analysis of a man's personality. A warm human interest in the man is much more desirable and helps one to understand his individual drives and ambitions.

This warm interest in the other fellow is something that many engineers and engineering managers neglect in their concentration on technical matters. We should remember that everyone responds to a genuine interest in his work, his family, his hobbies, or any of the things that are important to him.

COMMUNICATIONS

For engineering managers and leaders, the problem of communication is particularly important, because we are generally dealing with sensitive, highly motivated people. What to communicate, of course, is worth considerable thought, but let us concentrate here on the human factors entering into the problem of *how* to communicate. Engineers and engineering managers have the problem of speaking the other fellow's language, which requires putting ourselves in the other fellow's place, to see what he wants to know and what he can understand.

There are some blocks to good communication which we should consider. As Thoreau once said, "It takes two to speak the truth; one to speak, another to hear." If someone does not want to listen, or prefers to twist the meaning of our words because of anger, resentment, or a preset notion of our intentions, then we are not communicating. Sometimes our own expression, action, or previous attitude may speak louder than the words we are using.

In speaking to an individual, it is important to sense the other fellow's feeling by his facial expression and actions as well as his words as we start and as we proceed with our communication. "Feedback" is thus furnished to regulate our own words, to give us real control, and to prevent our rushing ahead blindly, expressing only our own ideas and feelings.

When an engineer is frustrated over his ability to progress toward certain personal goals, he frequently blames his troubles on the wrong thing and may even be irrational in his criticism and complaints. We are tempted to head off these arguments and gripes before the fellow commits himself to more irrational ideas. However, at such times it may pay to practice the art of listening. If we can let him talk while we listen, in-

terested but noncommittal, he will frequently go on to mention his real problem. Often, he prefixes the real problem by "and then, too" or words to that effect. In the statement of the real problem, before someone else, he may come to see the thing rationally and may suggest his own solution and even resolve right there to overcome the difficulty or accept some more realistic goal. If we can then step in and express confidence, still letting him make the decision, we have helped him and have improved our own understanding.

HUMAN FACTORS IN LEADERSHIP

THE ARTICLE previously mentioned discussed briefly certain factors in leadership, such as integrity, respect of the group, willingness to take responsibility, ability to create a team, ability to correct faults, devotion to the cause, and intellectual courage. We might now add a separate quality, the ability to motivate, although, in a sense, all of the foregoing enter into the art of motivating.

Specifically, the review of motivation and drives just discussed leads to some thoughts on attitudes and techniques engineering leaders can use. We have observed, for example, the power of recognition as motivation. What specifically can the leader do to help? First of all, his own demonstrated recognition of the value of a man's work is most important, and there are many ways to do this if one but looks for them. By letting the man tell you of his progress and problems, you are giving him recognition, as well as helping him to set his own objectives. Arranging for him to tell of his ideas or accomplishments to higher management gives him even wider recognition and shows that you consider his particular contribution important. Too often, for the purpose of saving our time and the boss' time, we tell the story instead of calling the man to tell of his ideas and, thus, we miss a very convincing form of recognition and resulting motivation. As mentioned earlier, the practice of arranging for your man to present his work before his fellows, either locally or at conventions, is double motivation because it shows your recognition and it gives him the opportunity to receive attention from his fellows. Incidentally, seminars on specific problems of a department provides a third advantage of spreading knowledge and the problems, and may stimulate someone else to contribute.

Providing a title or special privileges for a man of proven accomplishments is of some value; but only insofar as it is intended, and accepted by his fellows, as a true respect for the man's contributions. Although it is important to provide your men with adequate facilities and an environment reasonably comfortable and as free as practical from distractions, any luxuries or elaborate facilities adds motivation only insofar as it demonstrates a recognition of the importance of their work.

Other factors in motivation noted were the enthusiasm and confidence derived from the leader's attitude, which again emphasizes the importance of the leader's example in these things. Another factor was the need for confidence in ultimate success if a man is going to put forth his best efforts and induce his subconscious mind to work on his problems. An expression of confidence in the man by the leader can do much to establish this necessary feeling; and additional motivation is provided if it can be presented as a challenge, possibly in such words as "I know you can do it; here's your chance to show what you can do."

A negative challenge can sometimes be very effective. You may recall in your own experience where you did something to show up someone who said you could not or had not accomplished some specific thing. A negative challenge, however, frequently carries with it resentment and is not inducive to co-operation. However, if the man knows you are interested in him and that you judge results fairly, he may accept the challenge and appreciate being stirred to accomplishment by words that carry a sting.

Reminding people of the fruits of accomplishment, of course, supplies motivation, provided you make it clear that the rewards are the benefits the man really wants: recognition, prestige among his fellows, and a realization of his full potential. Another point to be remembered is that if the man doesn't know that you have his personal interest at heart, he may think you are reminding him of these things for your benefit, not his. The effectiveness of such motivation, then, depends not only on your sincerity, but also on the history of your relations with the man.

You have, no doubt, observed cases in which competition provided motivation. But where co-operation is necessary between these same people, competition can be a serious problem. A lot depends on the personalities and the degree of co-operation required; but if it cannot be on a reasonably friendly basis, generally one should try to get both men to subjugate their rivalry to the broader objectives of the group. In the same way, competition of the whole group with another can provide motivation plus a desired tendency to pull the group together as a team. But, again, if the competition is with another group with whom co-operation is required, it can be a handicap. It is better if they compete with the record of another company, or possibly with their own past record.

SOME PROBLEMS IN MOTIVATION AND HUMAN RELATIONS

PERHAPS we need to look at some special problems which can arise in applying these ideas. Consider the occasional case of conflict of interest which may arise between a development group and a design group, or between engineering and operating groups. The design group may resent the fact that the development boys get time to concentrate and work out the nice theoretical solutions; and the development man may feel frustrated because he solves a problem, writes a report, and then his idea may or may not be used, and he seldom has the chance to control its further development. This type of resentment may lead to lack of co-operation and may

lower motivation. If one can get these groups to feel part of a larger team working on the over-all project, we can hope to get them to co-operate and each to contribute his part.

How does one get people to feel part of the larger team? It takes good communications, specifically an exchange of ideas and an understanding of the over-all objectives. Sometimes a single leader can pull the two groups together, but many times they are in completely different departments, and it is up to the leaders of the two groups to get together and plan common objectives. Then it is desirable to get key people of both groups together, or at least consult such people in both groups about the combined objectives so that they all see what their contribution is and recognize the other fellow's part. We should try to get the design or operating man to see the over-all need of setting people apart for research and development; and to realize that he can attain satisfaction from seeing his project built, and that he will obtain recognition from commercial people and customers. In addition, we should have him understand that this recognition will come from results and from the use of everyone's ideas. On the other hand, we should try to make it clear to the development man that his chief recognition will come from his useful ideas, and that others must take over and carry them out. If his ideas are not used, the reason for dropping them should be explained clearly or his motivation is lost.

The recognition by one group of the importance of contribution made by the other is in itself motivation and a strong factor in real co-operation between the groups. The attitude of the leaders is, of course, reflected in the feelings and actions of the men. We have used design and development groups in this example, but the same type of problem may arise between other groups.

Problems sometimes occur when we deal with creative people and it is necessary to motivate strongly and yet retain reasonable control over their operation. As we have seen, many of these people have a strong need for recognition by their fellows. One difficulty may arise from their desire to tell the whole profession everything and to show how much they know, even though this may, at the time, be to the disadvantage of management. At times, real recognition by several levels of management and a chance to tell their story to the more limited group in the company, who should hear it, may satisfy the desire sufficiently to keep them motivated. Another type of difficulty arises when they think they will get their recognition from their fellows by some more elegant, if less practical, solution to the problem than the one management would be seeking. We do not want to discourage accurate analysis or essential theoretical work, yet, at times, it may be necessary to point out that the truly useful and lasting ideas are usually simple and practical, not necessarily elegant or complex.

Again, the whole idea of control and scheduling may cause some resistance among development engineers because they know that creative ideas and inventions cannot be achieved by straightforward, logical steps. However, if we show that we recognize this problem and are sharing the uncertainties with them, then we can help them see the need for planning, even without certainty of immediate results. The very risk and the many approaches required, tied to a target date, can become the challenge necessary to stimulate their best efforts.

CONCLUSIONS

An understanding of the strong motivation necessary for creative engineering and a warm human interest in the individual will help any leader of engineers to develop his people. One of the strongest drives is the desire for recognition from both their management and their fellows. Management must continue to give considerable thought to providing opportunities for deserved recognition, and to the many other human aspects of dealing with engineers.

The study of the human relations aspect of the engineering leader's job may well be as important as the technical and economic problems he faces. Many individuals have given this serious thought. However, until recently little has been written about these problems. It is hoped that this article will be of some help and stimulate further thought and discussion on these subjects.

230-Kv Circuit Breaker

A 15-million-kva short circuit has been successfully interrupted by this General Electric Company 230-kv circuit breaker at Grand Coulee, Wash. Tests by Bonneville Power Administration and U. S. Bureau of Reclamation were made in early morning to avoid interference with heavy daytime power demands. The big breaker interrupted this fault in about 1/20 second.

Measurement of Rotor Displacement Angle

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THE ROTOR DISPLACEMENT ANGLE plays an important role in the operation of a synchronous machine, because the power output and stability of the machine depends on it. This angle may be determined by calculation or measurement. The known methods of the direct measurement are applicable only during tests on synchronous machines. A new method for the measurement of the rotor displacement angle under normal operation of the synchronous machine is discussed in this article.

For a cylindrical rotor machine, the sine of the displacement angle, as derived from the vector diagram and the short circuit characteristic of the machine, is:

$$\sin \delta = \frac{m E_t I \cos \varphi}{m E_t I_d} = \frac{E_t I \cos \varphi}{K E_t I_f} \qquad (1)$$

where

E_t = terminal voltage, phase-to-neutral
I = armature current
I_d = steady-state short circuit current
I_f = field current
K = slope of short-circuit characteristic
m = number of phases
φ = phase angle between terminal voltage and armature current

In accordance with this equation, the indicator of the rotor displacement angle should consist of two wattmeters attached to the same shaft, deflection of which should be proportional to the ratio of power output to the steady-state stability limit of a synchronous machine.

A connection diagram of a rotor displacement angle indicator is shown in Fig. 1. The fixed coils of two dynamometers are located in one plane, but the moving coils are secured to a common shaft at right angles to each other. The voltage applied to the moving coil of the lower dynamometer *LD* should be rectified in order to obtain a constant torque from this dynamometer.

The deflecting torque of *UD* is proportional to the power output of the synchronous machine times the cosine of the deflecting angle. The deflecting torque of the lower dynamometer is proportional to the terminal voltage of the machine times the field current times the sine of the deflecting angle. At the balance of the moving system, the tangent of the deflecting angle will be proportional to the ratio of the power output to the terminal voltage times the field current.

In order to compensate for the saturation effect, the rheostat R_f is connected in series with the fixed coil of the lower dynamometer. The adjustment of resistor R_f is made through the movement of the shaft of the instrument in order to insure that the deflecting torque of the lower dynamometer will be proportional to the rise of the internal voltage of the machine.

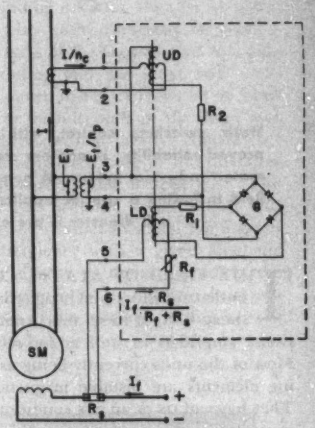

Fig. 1. Connection diagram of rotor displacement angle indicator for cylindrical rotor machines.

For a salient pole machine, the sine of the rotor displacement angle is

$$\sin \delta = \frac{E_t I \cos \varphi - \frac{E_t^2 (x_d - x_q)}{2 x_d x_q} \sin 2\delta}{K E_t I_f} \qquad (2)$$

where

x_d = direct-axis synchronous reactance
x_q = quadrature-axis synchronous reactance

The other symbols are the same as in equation 1.

Equation 2 shows that, in addition to the two wattmeters with the same function as in the case of the cylindrical rotor machines, a third wattmeter should be set on the same shaft for producing a torque proportional to

$$\frac{E_t^2 (x_d - x_q)}{2 x_d x_q} \sin 2\delta$$

The tangent of the deflection angle obtained by the action of the three dynamometers on the same shaft will be proportional to the right side of equation 2 and, therefore, will be proportional to the sine of the rotor displacement angle.

REFERENCE

1. Rotor Displacement Angle Indicator for Synchronous Machines, V. A. Kinitsky. *U. S. Patent No. 2,802,989*, Aug. 13, 1957.

Digest of paper 58-198, "Measurement of Rotor Displacement Angle on Synchronous Machines," recommended by the AIEE Rotating Machinery Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Feb. 2-7, 1958. Published in AIEE *Power Apparatus and Systems*, June 1958, pp. 349-53.

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Static Control for Wood Chip Chemical Digester for the Paper Industry

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Static switching control, with its greatly improved reliability, is another step toward automated industrial sytems. A general view of this field including a specific application to a paper mill digester is presented.

THE FIELD OF STATIC CONTROL includes both transistors and magnetic amplifiers (amplistats). Both of these are currently used for conventional amplifiers as well as for relaying or switching. Most of the units currently being used for static switching elements are bistable magnetic amplifier devices. They have an ON or an OFF condition which can be compared to the closed or open condition of a conventional relay contact. These units transmit or manipulate data or intelligence by being in either a saturated ON or desaturated OFF condition rather than being "picked up" or "dropped out." Transistor units are at the present time being used only to a limited extent in the switching field.

Fig. 1. Some "building blocks" or "modules."

In the field of amplifiers both transistors and magnetic amplifiers are being used very widely. Where relatively low gain regulators are required, a magnetic amplifier is used directly as the amplifying power output stage. For applications requiring modest gain, one stage of magnetic preamplifier is frequently inserted ahead of the power stage. For a high gain regulator, a transistor preamplifier may be located ahead of the magnetic amplified power output stage. The use of the transistor amplifier in place of the magnetic amplifier offers the advantages of practically no time constant and, therefore, no phase shift to transient or steep wave front signals. Transistors themselves are usually designed in a conventional electronic type of physical construction; thus, for use in regular industrial or mill equipment, they are often encapsulated in plastics. This frequently is done in combination with other resistors, capacitors, and small circuit elements to form integral stages of amplifiers as "building blocks." Fig. 1 shows an example of several of these building blocks or "modules."

The use of static control is expanding rapidly due to both the increased technical understanding necessary to apply the new components as well as the improved availability and dependability of them. The magnetic amplifiers require very dependable semiconductors (rectifiers) as well as high-grade steel; the transistors are themselves semiconductors and they must also be dependable. Selenium rectifiers have for years been very dependable but they display an aging characteristic as well as to allow more reverse leakage current and have a higher forward resistance drop than germanium or silicon. Both of these latter characteristics impair the operating efficiency and gain of a magnetic amplifier.

THINKING IN "LOGIC" TERMS

MOST ELECTRICAL ENGINEERS today have been trained and, therefore, think in the terms of interlocks and contacts. For them, learning a new method of transmitting or manipulating data is like learning a new language. For the proper and most efficient use of static control we must learn to think in logic terms. In a way, this is like learning a new language and when you deal with it at first you frequently find yourself thinking in terms of the old language (contacts) and translating mentally to the new language (logic terms). The elements are different. With relays and contactors you had one input and multiple outputs. With static control you have multiple inputs and one output. Designers who have become proficient at designing static control systems find it beneficial to learn to think in terms of logic terminology rather than thinking in terms of conventional terminology and then "translating." The logic terms that are involved are the same as those used in computer work such as AND, OR, NOT.

Fig. 2 shows several interlock configurations and their conversion to logic symbology. These are interpreted as follows:

1. The first interlock configuration shows interlocks for device *M* and device *N* in series, thus both must be

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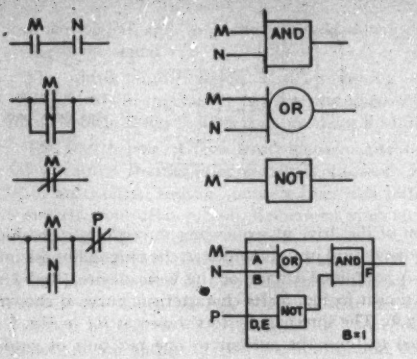

Fig. 2. Interlock configurations and their conversion to logic symbology.

closed to have a completed circuit. Translating this to logic symbology, we have the symbols shown on the right that says if there is an input at *M* AND an input at *N* we have an output from the device.

2. The second configuration shows the interlocks in parallel—if device *M* is energized or device *N* is energized we will have a completed circuit. In logic symbology this says if you have an input at *M* OR if you have an input at *N* you will have an output from the unit.

3. The normally closed interlock shown next is similar to a NOT unit. For example, if device *M* is energized you will not have a completed circuit and likewise if you have an input at *M* in the logic symbol an output is NOT produced from the unit.

4. The last relay circuit shown says that if device *M* OR device *N* are energized and if device *P* is not energized you will have a completed circuit. Now looking at the logic symbology we would say that if there is an input at *M* OR an input at *N* AND—NOT an input at *P* you will have an output from the device at terminal *F*.

MULTIFUNCTION STATIC SWITCHING UNITS

THE FAMILY of multifuction static switching units are designed around the single-phase amplistat. At this point some sort of explanation concerning the fundamentals of this device is in order. The single-phase amplistat consists of two "gate" (or power output) windings and, let us say for simplicity, only one control winding to provide an input control signal to the device. Let us now take two separate magnetic cores and wind one gate winding on each, then let us place a rectifier in series with each connected in such a manner that one-half cycle of the load current will pass through one gate winding and the other half cycle through the other, as shown in Fig. 3. Now, let us wind the control winding to include both of the cores and be wound in such a direction that positive control current will produce a flux in each core in the direction that will aid the load-current flux in that core. The load current in each gate winding is, of course, unidirectional because of the rectifier in series. For a given supply voltage and frequency with a given magnetic structure and number of turns on the gate winding, the output can readily be controlled by a given excitation on the control winding. If the control winding has the magnetic core completely saturated when the positive half cycle comes on for that gate winding, it (the gate) will offer essentially no impedance and the supply voltage will appear across the load. During the other half cycle, the other gate winding will conduct. Inasmuch as the rectifier blocks reverse load current, the core stays saturated and is immediately ready for the next cycle. If the control winding has the core unsaturated or with negative flux, the power supply half cycle is blocked by the impedance of the gate winding and, thus, the load sees (essentially) no voltage.

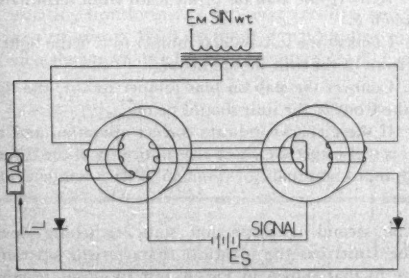

Fig. 3. Multifunction static switching unit.

Fig. 4. Typical multifunction static switching units shown mounted in the plug-in bus assembly.

The family of multifunction static switching units manufactured by General Electric Company Industry Control Department in Roanoke, Va., consists of just eight devices with the magnetic cores, associated rectifiers and resistors encased in a plastic compound and each different type identified by color as follows:

Red Unit—Multipurpose unit (two positive—three negative inputs).

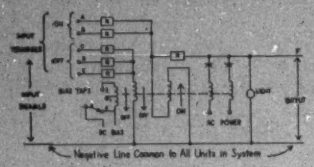

Fig. 5. Red multifunction unit.

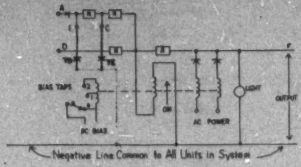

Fig. 7. Black long time delay unit.

Blue Unit—Multipurpose unit (three positive—two negative inputs).
Black Unit—Long time delay (up to two seconds on energization, 10 seconds on de-energization.)
Green Unit—Short time delay.
Purple Unit—Isolated input.
Brown Unit—OR rectifiers.
Yellow Unit—AND rectifiers.
Gray Unit—Isolation switch (isolated output).

The first five units are single-phase amplistats connected to give pulsating d-c full-wave output with positive feedback to give snap action. They operate at approximately a 6-volt level having an 8 milliampere input and 50 milliampere output. The other three serve as auxiliary devices to the first five. Two of this latter group are rectifiers used to combine input signals for a single input to a magnetic device. The eighth is used as a voltage isolating switch, thus duplicating one of the inherent qualities of the conventional relay.

The input signals from conventional push buttons, limit switches, and relays are usually applied to the static switching devices through dropping resistors. These bridge resistors place a drain on the power supply and should be kept to a minimum. The input signals may also be obtained from magnetic tape, punched cards or other low-voltage devices.

Terminals on the back surface of each unit plug into a fixed bus which supplies the power requirements. Quick-disconnect terminals for connection of input and output signals are located on the top front edge. The terminals on the bottom front edge are for control bias connections. A small telephone-type monitor light located on the front face of each magnetic device gives visual indication that the device is ON or OFF. This is of considerable help in setting up adjustment and trouble shooting a system as well as observing the progress of the drive in sequencing through its cycle. Fig. 4 shows typical units mounted in the plug-in bus assembly.

A simplified circuit of the basic device (Red Unit) is shown in Fig. 5. Its characteristic curve is shown in Fig. 6. The internal resistors shown as *R1* in Fig. 5 are used to limit the current to one per unit of ampere-turns through the control windings when a per-unit input signal is applied.

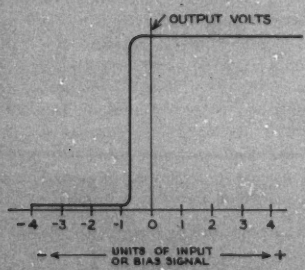

Fig. 6. Characteristic curve of red unit.

The bias winding terminals permit selection of the operating point so that the device may be either normally ON or normally OFF. These bias windings of all magnetic devices in the control system are connected in series and are supplied from a constant-current supply in series with an undervoltage relay to remove power if any unit loses bias. By changing the external connections to the individual bias windings, the device may have an operating point of 0, —1, or —2 units. It will then require respectively either 0, 1, or 2 ON signals to overcome the bias and saturate the device.

As an example of ON-OFF operation, if the device is at the point of zero control signal, and one per unit of signal is applied to one of the negative terminals (between common and terminal *C*, *D*, or *E*) the output voltage falls to zero between common and terminal *F*. Again, if the device is operating at —1 unit and a unit of signal is applied to the positive terminal *A*, a unit of output voltage appears between terminal *F* and the common bus.

The internal circuit employs a rectified full-wave voltage output which appears at terminal *F* as a ripple d-c voltage. This full-wave output allows freedom of interconection between units without regard to any phase relationship.

To check the proper operation of a unit, the following steps should be followed:

1. Remove the stab on input leads from terminals *A* through *E*.
2. Connect the stab on bias jumper to —0, the light on the front of the unit should be on.
3. Connect the stab on bias jumper to —1, the light on the front of the unit should be off.
4. If these checks indicate correct operation and the unit is still suspected, check the continuity of the control fields input terminals to "common" with a standard ohm meter.

The second multifunction static switching device (Blue Unit) has the identical characteristic operating curve to that shown in Fig. 6, but its input terminal connections have been modified to accommodate one

less OFF signal and to permit an additional double strength ON signal.

The third multifunction static switching device (Black Unit) in this family has the simplified internal circuit shown in Fig. 7. This is a time-delay device.

The fourth type (Green Unit) has a magnetic time-delay feature. Its simplified circuit is shown in Fig. 8. With an external resistor connected between terminals *C* and *D*, a time-delay pick-up is obtained when an input signal is applied to terminal *A* or *B*.

The fifth device (Purple Unit) is an isolated input device and is similar in operating characteristics to the basic device shown on Fig. 9, except that the control windings on the core are insulated for 750 volts with respect to the output or power windings and the bias windings. This permits voltage isolation of the control signals, a familiar feature of the conventional relay.

The sixth of the family (Brown Unit) is defined as an OR device in logic terminology. It performs this function by the use of four rectifiers connected as shown in Fig. 10. (This is a double unit with two sets of four rectifiers each.)

An input voltage applied to any one of the input terminals appears at the output terminal *F* for that set. This unit is used as an auxiliary device by combining as many as four different signals to a single input terminal of a magnetic switching device.

The seventh device (Yellow Unit) is shown in Fig. 11. It is defined as an AND device in logic terminoloy. It is a double unit having two sets of four rectifiers each connected so that if signals exist at all of the input terminals being used, a high impedance to the d-c source exists at these terminals and current flows from the d-c supply (terminal *A*) through the dropping resistor and out at terminal *F* for that set of rectifiers. This voltage divider circuit produces a per-unit output voltage at terminal *F*. If no input signal exists at any one of the connected input terminals, the current flows through that particular terminal rectifier, and through the low impedance of the connected device effectively short circuiting the output impedance. The output voltage is, therefore, very low and the device is OFF.

The eighth device (Gray Unit) is a static isolating switch. Its simplified internal circuit is shown in Fig. 12. The input signal is a d-c ripple voltage fed through an isolating transformer, a full-wave rectifier, and applied to a transistor. With no input signal applied to the device, the impedance between terminals *D* and *F* or *E* and *F* blocks current flow. When an input signal is applied, this impedance drops practically to zero. Since the input signal is effectively isolated from the output, this device duplicates the isolating switch function of the standard relay. The rectifier connected at *D* is germanium (used when a very low forward drop is desired), and that at *E* is silicon (used when a very high reverse resistance is desired).

MEMORY

PRIOR TO the advent of static switching, the generally accepted methods of obtaining "permanent memory" on a control system, when power was removed, were through the use of latching relays or stepping switches.

As aforementioned briefly, a static switching device is designed to provide for the characteristic of permanent memory or the ability to recover intelligence after system control power has been removed and then restored. This memory feature will be maintained in the device no matter how many times the control power cycle is ON and OFF. Briefly, the core remains saturated when power is removed, and the output voltage re-establishes itself when power is regained.

The static switching units will also be required to perform the functions of a sealed-in relay, or temporary memory; i.e., if power is lost and later restored, the unit will revert to its original condition rather than its condition when power was lost. The output of any unit can be fed back to a positive input of the same or a previous unit so that once the system has turned on, the feedback will hold the system on. The units will then stay on until sufficient negative input signal is received or the power is turned off.

There is no difference in the individual units or connections between temporary or permanent memory. The only difference is in the type of power supply furnished. Temporary memory is accomplished with a power supply that turns on the bias at least 0.1 seconds before applying a-c power. Permanent memory is accomplished with a different supply that sequences energization of the power buses as follows:

1. Apply power to constant voltage transformer.
2. One cycle later, apply bias circuit and a-c power at 90% voltage. This allows the d-c bias winding to build up at the same rate as the a-c and the state of the unit is thus determined by the existing core flux.
3. Two cycles later apply full voltage.

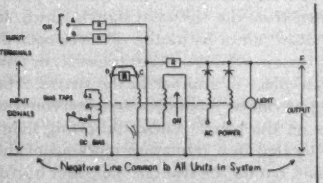

Fig. 8. Green short time delay unit.

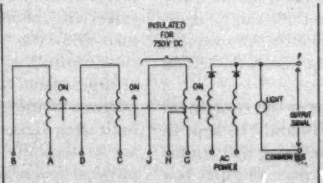

Fig. 9. Purple voltage sensitive unit.

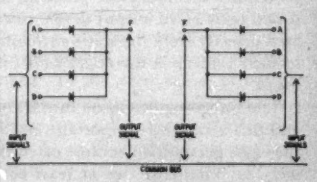

Fig. 10. Brown rectifier OR unit.

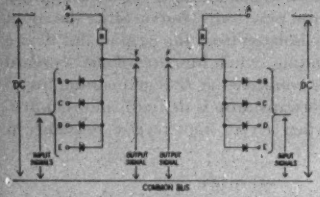

Fig. 11. Yellow rectifier AND unit.

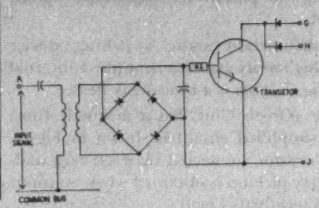

Fig. 12. Gray isolated switch unit.

INITIAL COST CONSIDERATIONS

PROBABLY, the two major factors in determining the "initial cost economics" of a static switching system are the cost of the power supply and the cost of the output amplifiers.

To help understand this, let us examine an example. First, let us see the effect of the cost of a power supply on the cost of a static control system. The minimum size power supply will handle 10 inputs and 50 (multifunction static switching) units and costs about as much as 5 units. The next size power supply will handle 16 inputs and 150 units and costs only as much as 7 units. Thus, an application where 5 units would be required would cost equivalent to 10 units when the power supply is considered while a system of 150 units would cost equivalent to only 157 units when the power supply is considered. In this example, the cost "adder" for the power supply dropped from 100% to 5% as the size of the system grew. Thus, when considering first cost of equipment we can say an application of static switching would appear more economical for a large system than for a small system.

The second factor determining the initial cost economics of applying static switching is the number of output amplifiers. An output amplifier is equivalent in cost to about five multi-function units and usually does not, in itself, contribute anything to the system other than changing the level of power. Data may be manipulated within the logic units and then when it is necessary actually to perform a function, the output signal must go through a power amplifier to operate the contactor, to opérate the solenoid, to change the excitation on the saturable reactor, etc. Thus, the number of outputs will have a definite bearing on the initial cost of a static switching system.

Under certain conditions, the output device functions fewer times compared to the other devices and handles relatively low power levels. For these applications, it sometimes becomes more practical to use a hermetically sealed relay as an output device since these can be operated directly from the static switching unit. An example of such a device is the *IC2828A101* shown on the left in Fig. 1.

The foregoing dwells on initial cost of the equipment and this is certainly important, but it should be kept in the right perspective because often the thing that counts more is "final cost," or at least cost over the first few years; i.e., when we compare static switching to conventional relay systems, we must factor in such items as resistance to difficult climatic or atmospheric conditions, the reduced maintenance and greater reliability over the relay systems. The unscheduled interruption of a complex process can frequently be more costly than the initial cost of the electrical equipment involved.

STATIC CONTROL FOR A PAPER MILL DIGESTER

THE APPLICATION of static control to a specific application is an installation on a paper mill digester. This is an example of "program control." Program control is a step toward automation in the series of evolution of control which started with "manual," progressed to "magnetic," then to "semiautomatic," then program control, which is actually a type of automatic control. In this application, the type of operation that is desired can be preselected by setting the selector switches and timers at the desired values and, when the process is initiated by the operator pushing the "start button," it will then go through its preselected program. The program is monitored all the way by limit switches, pressure switches, and other feedback sensors. The various "pilot" valves are operated from the electrical signals which, in turn, allow the "main" air or hydraulic valves to open or close controlling the air pressure, steam pressure, or flow of liquor from one place to another in the system. The progress of the cycle can be monitored by observing the indicating lights on the panel. These indicating lights are strategically located in a miniature mock-up of the physical system laid out on the front of the panel board.

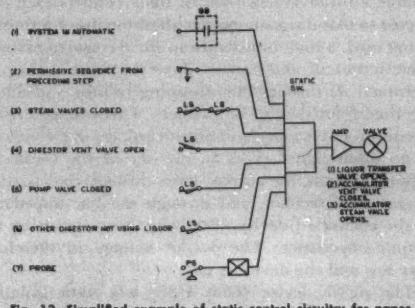

Fig. 13. Simplified example of static control circuitry for paper mill digester.

The normal steps that the digester goes through for a "batch" are as follows: chip loading, presteaming, liquor

filling, impregnation, liquor return, cooking, and blowing (also, refill of liquor accumulator as necessary). The first step of the initial batch is initiated by the operator, then each step is initiated as a function of the completion of the preceding step. This initiation is done as a timed program on some steps and as a limit switch indicating that the last step of the cycle has been successfully completed on others.

BRIEF EXPLANATION OF CIRCUITRY

FIG. 13 SHOWS a simplified example of the circuitry involved in this type of application. This portion of the circuit controls the liquor-filling portion of the cycle for one digester in a dual installation, but involving only one liquor accumulator. This circuit is read as follows: If (1) the system is on automatic, (2) the preceding step in the cycle has been completed, (3) the steam valves in this digester are closed, (4) vent valve is open, (5) the pump valve is closed, (6) the other digester is not using the liquor, AND (7) the probe has not been actuated, then the liquor-transfer valve opens between this digester, and the liquor accumulator which, in turn, closes the accumulator vent valve and opens its steam valve to press the liquor from the accumulator into the digester.

This circuit, as shown, accomplishes its assignment and is very simple inasmuch as it accomplishes just this one function. In actual practice, this one function is interrelated with the others; for example, this same amplifier must operate this same (liquor transfer) valve for the "liquor return" as it did in the cycle examined which was "liquor fill." This requires several static switching units maniuplating the signals to control this one amplifier in place on the one AND unit shown. However, it is of this same type symbology and each function could be isolated as shown in this example.

DESCRIPTION OF OPERATION OF THE SYSTEM

ASSUMING THAT: (1) the chip bin is full; (2) the diter under consideration is empty; (3) the necessary steam, air, liquor, and vent valves are in the correct position (opened or closed); and (4) pressure in the digester is below the minimum value, the automatic cycle can be initiated by the operator. When this is done, the following takes place:

The chip loading is started—taking chips from the bin and transferring them to the digester. As the chip bin starts to empty out, it will be refilled automatically. The chip loading continues for a definite time as preselected by the operator.

As a function of the limit switch indicating the chip-loading valve is completely closed, the presteaming cycle is started. This continues for a definite time. At the conclusion of this time, the valves are closed, the liquor filling valve is open and the digester is filled with sulfite liquor until the liquor probe is actuated.

High-pressure steam is then admitted to the digester for the "impregnation" portion of the cycle. This is carried on for a definite time interval. The next step in the program is to return the liquor from the digester to the liquor accumulator. This is again done as a function of a definite time interval.

At the conclusion of this time interval, valves are again reclosed and the "cooking" cycle starts. The cooking continues for a definite time interval and at the conclusion of this time, the tank is "blown out," and the cycle is completed for this "batch."

ADVANTAGES OF THIS TYPE OF CONTROL

THE FACT that there are no moving parts when data is manipulated by a change in magnetic characteristics internally in the units give this type of control advantages over conventional control. For application where there are either: (1) a large number of operations, thus the mechanical parts would wear out in too short a time; or (2) if there may be difficult atmospheric conditions where conventional relays may wear out in a shorter time or become unreliable in operation—static components offer advantages since the parts in these units are sealed and isolated from the atmosphere. These inherent advantages will yield greatly reduced maintenance on this type of control.

SPECULATION ON WHAT THE FUTURE HOLDS

AVAILABILITY of new pilot devices and sensors will help to advance the science of static control. Readily available, reliable, static sensors for all of the different quantities manipulated and controlled such as pressure, temperature, position, etc., must be made available to indicate the process qualities and quantities. To speculate for a moment as to what advances in the art might be expected in the near future, we would undoubtedly consider the much wider application of transistors and possibly the introduction of some radically new elements, if they can be reduced to practical applications such as transistors and the magnetic amplifier have been over the last decade.

SUMMARY

CLOSED LOOP REGULATORS are commonplace in control systems today. The introduction of static amplifiers to help make these closed-loop regulators more reliable is just coming into being. Static switching systems are just now starting to make a mark in the electrical engineering field. As we go forward into more and more complex systems involving data processing, data read out and recording, director systems, etc. this new tool of static switching will be a big aid to the control system designer. It will allow him to simplify some of the more complex systems. The main advantages of static switching, however, lie in ultimate user benefits such as reduced down time, less maintenance, and greater reliability. As we continue to progress in the field of automation, reliability will be a major factor. In the application of more and more complex equipment, greater reliability is needed to keep the systems from falling under their own weight and complexities. Thus, this big step forward in the development of static switching control with its greatly improved reliability truly is another step toward automated industrial systems.

Servo Analysis by the Ritz–Galerkin Method

KATSUHIKO OGATA
ASSOCIATE MEMBER AIEE

C. P. ATKINSON

A THEORETICAL INVESTIGATION of a second order servomechanism with backlash was recently conducted. In the absence of a driving force, such a system may exhibit hunting phenomena in which the system oscillates with a certain amplitude and frequency. The Ritz–Galerkin method has been used for finding the hunting frequency and hunting amplitude of such a system. Theoretical results which were developed were found to agree with experimental results obtained by means of an electronic analog computer.

The Ritz–Galerkin method can be outlined briefly as follows: Given a differential equation

$$F(m,\dot{m},\ddot{m},t) = 0 \tag{1}$$

In the absence of an exact solution, the assumption is made that

$$m(t) = \sum_{n=1}^{n} (A_n \sin n\omega t + B_n \cos n\omega t)$$

The Ritz–Galerkin method then requires the calculation of the integrals of the form

$$\int_0^{2a} F(m,\dot{m},\ddot{m},t) \sin n\omega t\,dt = 0$$

$$\int_0^{2a} F(m,\dot{m},\ddot{m},t) \cos n\omega t\,dt = 0 \tag{2}$$

where $2a = 2\pi/\omega$, the longest period of the components of the solution $m(t)$.

The evaluation of the integrals in equation 2 yields the Ritz equations which are algebraic equations for the solution of the constants A_n and B_n in terms of ω.

The system shown in Fig. 1 consists of an amplifier, a motor, and a gear train. The inertia of the gears is considered negligible as compared to that of the motor. Fig. 2 shows the relation between $m(t)$, the output signal of the motor, and $c(t)$, the output signal of the system.

In order to find the hunting frequency and amplitude of this system, the wave of the $m(t)$ signal has been assumed to be a cosine wave,

$$m(t) = M \cos \omega t \tag{3}$$

Then the Ritz–Galerkin method requires the evaluation of the following integrals:

$$\int_0^{2a} [T\ddot{m} + \dot{m} + K\,c(t)] \cos \omega t\,dt = 0 \tag{4}$$

$$\int_0^{2a} [T\ddot{m} + \dot{m} + Kc(t)] \sin \omega t\,dt = 0 \tag{5}$$

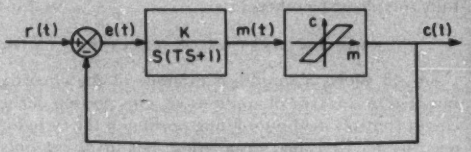

Fig. 1. Block diagram of system.

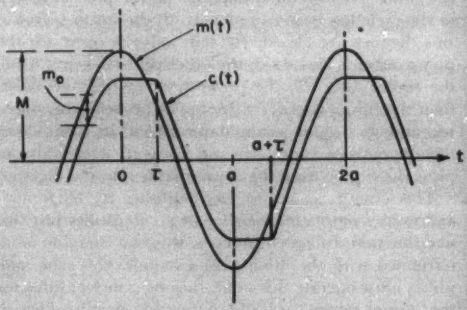

Fig. 2. Relation between m(t) and c(t).

where $2a$ is the period of the $m(t)$ signal. The evaluation of equation 4 yields the following equation:

$$\left(1 - \frac{T\omega^2}{K}\right)\pi = \omega\tau - \frac{1}{2}\sin 2\omega\tau \tag{6}$$

where

$$\omega\tau = \cos^{-1}\left(1 - \frac{2m_0}{M}\right)$$

M is the amplitude of the $m(t)$ signal and m_0 is the backlash amplitude as shown in Fig. 2.

Evaluation of equation 5 yields the following equation:

$$\frac{\pi}{K} - \frac{4m_0}{\omega M}\left(1 - \frac{m_0}{M}\right) = 0 \tag{7}$$

Equations 4 and 6 show the relations between M/m_0 and ω. The simultaneous solution of these equations yields the hunting frequency and amplitude.

Digest of paper 58-86, "An Analysis of a Servomechanism with Backlash by the Ritz–Galerkin Method," recommended by the AIEE Feedback Control Systems Committee and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., Feb. 2-7, 1958. Published in AIEE *Applications and Industry*, May 1958, pp. 82-85.

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Photograph of Professor A. F. Joffe taken by the author in his office at the Institute of Semiconductors, Leningrad.

A Scientific Tour through the Soviet Union

W. C. DUNLAP
MEMBER AIEE

Report of a 3½ week tour of the Soviet Union during which five important solid-state research laboratories were visited. The Soviet people, in general, were found to be vigorously competing with the United States in all fields and optimistic over the chances for peaceful coexistence.

AMERICANS have been aware for many years of important Soviet contributions in the solid-state field and related areas, as well as in the areas of nuclear physics, cosmic rays, guided missiles, and metallurgy. In the last few years, this awareness has led to the translation by a special agency of the American Institute of Physics of several of the important Soviet physics journals. In particular, interest has been stimulated by the reports of spectacular Soviet success, particularly in the laboratory of A. F. Joffe, in applying the Peltier effect to cooling small volumes simply by the passage of current through special conducting elements. However, no physicist from the solid-state field or related areas had made any extensive trips there although the Soviet Union had been relatively open to tourists from the United States for about a year. Inquiries confirmed that assumption, and hence I resolved, in the Spring of 1957, to try to become the first American in my field of physics to visit Soviet laboratories and to meet their leading research people.

After several attempts to find a means of official Soviet or United States recognition of such a trip with no appreciable success, I wrote individually to a well-known Soviet scientist, A. F. Joffe, and a month or so later received a reply containing the phrase "I should be glad indeed to meet you and to discuss some problems of semiconductors." Although this was a rather slim basis upon which to base such a long trip, I decided to take a chance anyway.

I left the United States on November 5, 1957, and arrived in Paris by noon of the 6th. There, I visited the Physics Laboratory at the Ecole Normale Superieur, where I was able to renew acquaintances with Professor Pierre Aigrain and a number of his students and associates. In particular I chatted with M. Balkansky, who is doing interesting work on the diffusion of excitons in cadmium sulfide. These excitons are bound combinations of an electron and positive hole, and the description of their properties is now becoming one of the most rapidly developing frontiers of solid-state physics.

VISIT TO DR. JOFFE'S LABORATORY

I ARRIVED IN LENINGRAD, after stops in Stockholm and Helsinki, at midnight of November 11th. During the next 3 three days I visited Joffe's laboratory, which is located along the Neva River in the building formerly occupied by the French Embassy in the Czarist days.

Dr. Joffe, one of the most distinguished of Soviet scientists, is pictured in the accompanying photograph. A member of the Soviet Academy of Science since 1920, he is not only the oldest Academy member both in age and years of membership, but he is also remarkable in that more of his students and proteges have become members of the Academy than those of any other Academician. He has also founded more Institutes of the Academy than any other Academician. He has founded 15 in the past, and today, at the age of 78, is engaged in the founding of a 16th, an Institute of Agricultural Physics (also in Leningrad). He expects to spend alternate days at the new institute for the next six months to a year, when he will turn over the administration to a younger associate. On two of the three days I visited him he made a special trip back from the new institute to the Institute of Semiconductors where we had our

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discussions. Professor Joffe is typical of the "Old World" scholar in his bearing, attitudes, and conversation. He is extremely courtly, and polite in his conversation. He is also highly wrapped in science and I found it difficult to draw his attention to other matters. He, according to reports, was one of the Academicians who led the movement in the Academy during the first days of the Revolution to keep the scientific work of the Academy at the same high level of basic work that it had done before the World War I under the Czarist regime. This tendency was broken up in 1929 when the Academy was removed from Leningrad to Moscow and politically "correct" scientists were moved into the top administrative positions. Today Professor Joffe is regarded as an "independent" who because of his age and enormous prestige is given a great deal of leeway in the administration of his own laboratory. He also has great influence on the conduct of research in the Soviet Union as a whole.

Professor Joffe speaks English very well as a result of having spent a year in the United States lecturing at the Massachusetts Institute of Technology and the University of California. However, he says that until last year he had no further opportunity to leave the Soviet Union and to visit English-speaking countries, and has had little contact with Americans during that 30-year period. Now, however, as a consequence of the general relaxation evident all over the Soviet Union, he makes foreign trips fairly regularly, and is chairman of the Semiconductor Commission of the International Union of Pure and Applied Physics. This Union sponsored a large international conference on semiconductors in Rochester, N.Y., in August which Prof. Joffe attended, along with several of his research staff.

JOFFE'S WORK ON THE PELTIER EFFECT

ON THE FIRST DAY of my visits at the Institute of Semiconductors Professor Joffe showed me the work for which he and the Institute are most famous, that dealing with the Peltier effect. In this effect, current passing through a metal-semiconductor contact tends to cool the junction if passed in one direction and to heat it if passed in the other direction. By proper choice of materials, we in the United States have succeeded in cooling a junction 40 or 50 C. Professor Joffe says that with new materials they have recently developed, they can cool a junction by 80 to 90 C (160 F). Also, for cooling small volumes, he feels that these junctions are more economical than compressor units. He showed me a group of about 15 applications which are now being developed for commercial use. Most important is a small (apartment size) refrigerator having no moving parts in the cooling system. A set of vanes extends out of the back of the refrigerator, and the cool junctions are connected to a cooling plate inside. The interior is about 30 C cooler than the outside. No provision is made for making ice and, in general, this type box will not be effective for making ice. Professor Joffe feels that this cooler will be made in great quantities in the Soviet Union, and that it will be very cheap, since the material used in the elements is very cheap. Other applications of the Peltier effect include a trap for moisture and oil vapors in vacuum systems, which may render unnecessary the use of liquid-air traps in such systems. Another useful application is their dew-point hygrometer, in which a mirror surface is cooled by the Peltier effect until dew forms. This device is limited in range to about —40 C because of the geometry and the particular materials used. An interesting instrument application is the microtome sample cutter, which enables the freezing of small biological samples during cutting so as to make better sections and minimize the thermal damage from the high speed cutting edge.

Still another important although related area is the conversion of heat into electricity through the thermocouple effect (Seebeck effect). In this effect, if a metal semiconductor circuit is heated at one junction, an emf is formed whose value depends upon the temperature difference between the hot and cold junctions. Although the efficiency for power conversion is in general small, less than two per cent being common in this country, Joffe now claims values as high as ten per cent. He showed me a converter now being manufactured in large numbers in the USSR that enables the operation of a small radio from a kerosene lamp. The output of the converter is about 3 watts of electric power.

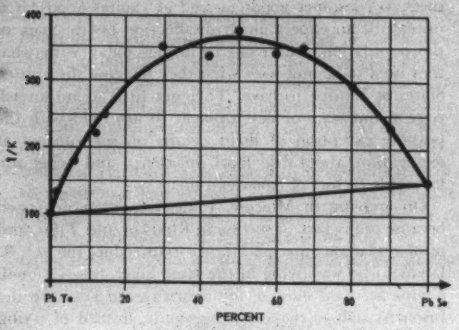
SCOPE OF ACTIVITY

MUCH OF THE PHYSICAL RESEARCH in the Institute for Semiconductors is related to these applications, to the search for new materials exhibiting the desired effects, and to the improvement of the older materials. However, much basic work on the quantum theory of solids is also being done. In particular, there is a whole theoretical group attempting to revise the basic theory of semiconductors to put it on a sounder basis. Joffe feels that the theory of semiconductors is weak because it was derived from the band theory of metals, which he feels is not as applicable to semiconductors as the theory of insulators is.

Most of the work on semiconductors is done on compounds, and relatively little is done on germanium. Joffe feels that germanium and transistor work is done in many other places, and he prefers to work in areas where more pioneering is possible.

I visited a number of the individual laboratories in the Institute, and had the opportunity to see many of the research setups, and to talk to many of the research people. I was highly impressed by the high caliber of the work being done, and by the ability and enthusiasm of the people doing the work. There was apparently a good supply of equipment, although Professor Joffe did admit, in response to a direct question, that the research equipment available to him was not what he would like, either in quality or quantity. All, or almost all, the research equipment I saw was either laboratory-built, or built by Soviet industry.

Many of the research workers in the Institute were middle-aged women, some of whom had been working



Reciprocal of the thermal conductivity (top) and carrier mobility (bottom) for the system lead telluride–lead selenide.

with Professor Joffe for many years. One of these is now his wife, Mrs. A. V. Joffe, who has collaborated with Professor Joffe in the publication of many research papers.

Among the interesting projects being carried out by those working directly with Professor Joffe is the study of the material parameters of importance for the Peltier effect. To get maximum use from this effect, the thermal conductivity must be reduced, without impairing the conductivity of the material or the mobility of the carriers. This project involves the study of mixtures of such materials as lead selenide and lead telluride. The illustration shows how the thermal conductivity drops by a factor of 10 while the mobility of the carriers actually increases slightly when a 50 to 50 per cent mixture of the two materials is made. Other systems being used actively in this work are the selenides and tellurides of both bismuth and arsenic. Professor Joffe would not divulge those particular mixtures with which they are presently getting the best results.

Among the other groups in this laboratory that I visited were those of B. I. Boltaks and V. P. Juse, both internationally known for their semiconductor research. Boltaks is doing the same kind of research that I personally have engaged in during the last few years, especially the study of the electrical activity and atomic diffusion of a number of interesting elements in germanium, such as gold, iron, and nickel. He and his associates are apparently still well behind us in this field, and as far as I could discover have produced nothing novel in this field as yet.

Juse's group is studying another area in which I have had interest for a long time, namely the development of devices using the galvanomagnetic effects, such as the Hall effect, Nernst, Ettingshausen, and magneto resistance effects. He and an associate, Mr. Bogomolov, have recently developed an harmonic analyzer using the Hall effect, which they feel has much promise. In this device, a complex waveform is impressed on a germanium crystal as a sample current, while the crystal itself is in a magnetic field on which is applied a sinusoidal field of variable frequency. A d-c galvanometer reads the Hall output voltage which is determined by the average value of the product of the current and magnetic field, and therefore reads the component of the wave form having the same frequency as the magnetic field frequency used.

From Leningrad I went by plane to Kiev, where I had written to the Academy of Science previously, but had received no reply. On arriving in Kiev I contacted Dr. S. I. Pekar, whom Professor Joffe thought I should contact because he would undoubtedly know of my work and, therefore, be more interested in a visit. This approach, here and in Moscow turned out to be the proper one, since I was unsuccessful in gaining access to laboratories where my work was undoubtedly not known personally to one or more of the research people.

KIEV INSTITUTE OF PHYSICS

At Kiev I visited the Presidium of the Academy of Sciences, and the Institute of Physics. Although I arrived on a Saturday afternoon, I was fortunate in that Pekar was interested enough to come into town to chat, and at that time he invited me to present a talk on American semiconductor research at the Institute of Physics. The talk was given on Monday, to an overflow crowd at the lecture hall of the Institute. Besides the Institute research staff, the research people from Kiev University and from the Physicotechnical Institute of Kiev were present. After the talk, I had the opportunity to meet most of the senior research people from these three places, the most prominent of whom are Professors Deigen and Lyachenko, and Drs. Miseluk, Tolpygo, and Rashba.

The Kiev Institute of Physics is charged with the responsibility of developing the physics and technology of semiconductors of particular importance industrially and, hence, most of its work is on germanium. Although the laboratory does much work on germanium devices including rectifiers, transistors, and photocells, I was unable to gain access to any of these device laboratories. It did appear quite definite from a number of statements that were made that very little was being done on silicon, and that little was very preliminary in nature.

I visited practically all the research rooms in the Institute, which houses all together about 400 people, although only about one third work directly on semiconductors. The rest deal with dielectrics, nuclear physics, and electronics. Again, I was impressed by the general program, the class of the equipment, and the caliber of the people, but was still impressed by the idea that the work was several years behind that of our leading laboratories insofar as results were concerned. In none of these laboratories did I learn of a single really outstanding new semiconductor discovery not already known in the United States.

On the other hand, I did get the feeling that theoretically, and particularly through the work of Pekar himself, that the Soviets are thinking ahead of us on the basic theory of solid-state and of semiconductor materials and devices. Even though this laboratory was expected to work on development to some extent, the basic research work led right back to the most basic

quantum mechanical studies that one could find anywhere in the world. Sooner or later this combination of basic and applied activity is likely to bear fruit in outstanding work of both theoretical and applied nature.

The only Soviet transistors that I observed personally were in the Kiev laboratory. These were incorporated in laboratory equipments for routine experimental work, and little could be gained by physical inspection. The research people refused politely to discuss their characteristics or construction. However, Tolpygo and Rashba were eager to discuss general theories of p-n junction devices, and such properties as the variation of alpha with emitter current.

From Kiev I went to Odessa and from there to the Crimea, across the Black Sea, to the resort area of Sochi and to Tiflis in Georgia. The only spots of technical interest here were Odessa and Tiflis. Odessa I was obliged to go through rapidly because of the boat schedule, and the fact that I had fallen behind schedule in Kiev.

We went from Odessa to Simferopol and Yalta by plane, and there took the large Black Sea liner *Georgia* across the Black Sea to Novorossisk, Tuapse, and Sochi. We stayed at Sochi several days, and made some excursions into the regions of the high Caucasus Mountains. Sochi is subtropical in climate, and the leaves were still green on most of the trees even at the end of November. Palm trees, bananas, and bamboos also thrive here because of the warming influence of the Black Sea, although the latitude is roughly the same as that of New York City.

In Tiflis I worked rather hard to gain access to the Academy of Science and also the State University, without success. Here it seemed that, because there was no one actively interested in semiconductors who might know of my work and who might therefore wish to converse, no one would take the responsibility of getting me in. Several times interviews were apparently arranged, and then something would happen to cause them to be canceled. The same thing happened at the Georgia State University.

Again at Kharkov I had the same difficulties as at Tiflis, although in this case it did appear that the people whose names I had really were out of town at a conference in Moscow. In Kharkov I had to be satisfied with two visits, one to a state cattle breeding farm which also had a small agricultural research institute, and one to a large factory where locomotive electric motors and huge electric generators in the 100,000 kw class for hydroelectric power projects were being made. At least half of the effort of this plant was going into plant expansion rather than construction of the product itself, and this kind of effort in the Soviet Union appears to be the rule rather than the exception. Hence, it is important to evaluate production figures with this in mind, because it is clear to me that 10 years from now the production capacity of USSR industry will be quite a different thing than it is today. Because of this, the general Soviet tendency to talk about "tomorrow" and "next year" with an attitude of great hope and expectancy may have justification. Because the situation is improving also with respect to consumer goods as well as capital goods, it is unrealistic to expect much disaffection on the part of the population, who compare things today with what they used to be, not with what they imagine the United States or Europe to have. They get little or no knowledge of our state of development in any field with the possible exception of lurid details on such things as segregation, the Little Rock incidents, and other unfavorable factors of American life.

On arriving in Moscow, I was somewhat depressed because of my lack of success in Kharkov and Tiflis, and presumed upon an acquaintance to introduce me to I. R. Levine, who was living in the same hotel, the National. Levine ascribed most of my difficulties to allowing the Intourist staff to make arrangements, instead of trying to reach people directly by any means whatsoever. He described local telegrams as being the most effective way to do this, since telephoning by a foreigner is difficult if not impossible.

LABORATORY OF PETER KAPITZA

USE OF THE TELEGRAM STRATEGEM was successful, and in Moscow I succeeded in visiting three laboratories, two in or near Moscow State University, the other being the Institute of Physical Problems headed by Peter Kapitza, the noted Russian physicist who received most of his scientific training in England. When he returned to the Soviet Union for a conference in 1934, he was not allowed to leave, and has been there ever since. Although there have been many reports of his difficulties with the government, and of his work on secret projects, he sidestepped discussion of these matters and his well-known absence from public activity for six or seven years, until 1955.

Kapitza was most co-operative in showing me his institute, although he was not very communicative regarding the specific research problems on which the staff was working. All he would indicate was that about one third the program was devoted to superconductivity, one third to superfluidity, and one third to miscellaneous projects the most important of which was antiferromagnetism. This Institute was the best equipped of any that I saw in the USSR. Excellent metal working machines, grinders, and lathes were present in numbers, while there was a great supply of meters and instruments of high quality, as far as one can judge by superficial examination.

Kapitza is probably one of the most influential scientific men in the Soviet Union. He is a member of the Presidium, the inner circle of 15 or so of the 100 or more academicians, who control the policy making, the programming and scheduling, and the financing of science in the Soviet Union. Although I observed that individual scientists have a great deal of freedom in the conduct of their work, nevertheless, the general outline of the program, and in particular the assignment of specific practical tasks considered to be of great importance, is certainly dictated by these few men in Moscow.

The other visits I made in Moscow were to the Physics Department and to the Cryogenics Laboratory at the

State University. Here I met Professor Kalashnikov, Dr Bonch-Bruevich, and others of the staff of the semiconductor group there. Here again, the same kind of situation was met as in the other laboratories, that good equipment and good experiments were in evidence, without anything outstanding being evident that would indicate that the Soviets were doing much more than trying to catch up with American developments. I did see some excellent student laboratories, where undergraduates were being given laboratory training in the research techniques of semiconductors that were the equal if not superior of those available to our students in graduate school.

GENERAL IMPRESSIONS

GENERALLY SPEAKING, there appeared to be an air of enthusiasm and expectancy about Soviets generally, as well as scientists, which leads one to believe that they will be even more active in the future than in the past. Much of their attention focuses on the United States, to a degree that seems hardly possible unless one actually sees it at close hand. Every phase of life in the United States is studied by them close up from the sources available to them, with the idea that this is the competition, and the USSR must equal or beat it. This competitive attitude may be fostered or initiated by the government propaganda, but in any case, the effects are there, and we are in this competition whether we realize it or not.

For the same reasons, there appear to be few, in any, strong opponents in the population to the policies of the government. Kruschchev is regarded as an improvement over Stalin, and the present regime is regarded as an improvement over the Czarist regime. As long as conditions continue to improve, one can hardly doubt that popular support will continue to exist. Even though there are signs of the "new class" appearing as technicians, scientists, bureaucrats, and others with a relatively high standard of living, the "little people" at the present time accept the idea that the country is now "their" country, and the state "their" state.

That there is a new hierarchy of relatively wealthy people in the Soviet Union is quite evident. Whereas the income of some of the workers I saw was only 500-600 rubles per month ($60–$125 per month depending upon how one adjusts the exchange rate), men like Kapitza at the top of the scientific ladder make an annual salary of perhaps 20,000 rubles per month, about $2,000 per month. Such people have developed their exclusiveness to the point where they no longer take their vacations at the "popular" resorts on the Black Sea, such as Yalta and Sochi, but have their own exclusive resorts where the prices are so high that very few people can afford them. With such sources of income, people like Professor Joffe indicated that they had far more money coming in than they could possibly spend.

The Soviet people impress one as being rather well educated in general, and to have a very moral and intellectual outlook on life. Life can of course be regarded as highly dull in our sense of the term, since there are very few distractions of the kind we prefer. Outside of the "highbrow" entertainments such as drama, opera, and ballet, there is very little entertainment except the circus and the movies. The movies are good, by Soviet standards at least, although their propaganda content renders them uninteresting to an American.

Book-reading is a standard vocation, and "heavy" novels are as likely to be read by the elevator operators and floor maids in the hotels as are the lighter magazines, most of which are cultural picture magazines roughly similar to our *Life*. Of course, there are no comic books, confession magazines, or even tabloid newspapers, so the Soviet man in the street must take intellectual fare or do without.

CONCLUSION

SUMMARIZNG, the activity of the Soviet people in all phases of life is accelerating both in quality and in quantity, and they have their eyes on the United States in everything in which they are engaged. This is not always a hostile reaction, of course, because the Soviet individual has more of an attraction and an admiration for things American than the opposite. Everywhere, the individual Soviet expresses a desire for peace and cooperation between these two great nations, and surprisingly, has a more optimistic attitude that it will be achieved than do we Americans.

Missile Steering Control

Simplicity has been a prime factor in the design of an electrohydraulic steering control system developed for missiles by The Garrett Corporation's AiResearch Manufacturing Division.

Possessing superhuman reflexes and enormous power, the system is uniquely adaptable to control the positioning of steering surfaces, "jet-avators," jet engine exhaust areas, nozzle, and vector steering controls It converts low-level electronic signals from a missile's main guidance system into hydraulic forces which actuate directional control mechanisms.

A feature of its simplified design concept is the use of "hydraulic printed circuits," analagous to electrical printed circuits. It combines manifolds and mounting structures in a series of integral passageways, eliminating all external plumbing and leakage.

The mounting, carrying servovalves and control actuators, produces a compact, rugged package with a high degree of stability and reliability even at extreme temperatures.

As the missile races toward its target, the responses and forces converting electronic guidance signals into control surface positions adequately provide for overall missile dynamic performance meeting rigorous specifications.

Explorer IV

SUCCESSFUL launching of the Explorer IV scientific Earth satellite is the U.S. Army's contribution to the over-all Department of Defense program with the International Geophysical Year (IGY) research program, which is sponsored by the National Academy of Sciences. The weight of Explorer IV is 25.76 pounds for the satellite proper, 12.67 pounds for the final stage after burnout, or a total orbiting weight of 38.43 pounds. The dimensions are 34 inches in length for the satellite proper, 46 inches in length for the final-stage motor, or a total length for the orbiting vehicle of 80 inches. The diameter of the satellite and of the final stage is six inches.

External cylindrical configuration of the newest satellite is identical to the earlier ones. In the first picture at the top left of this page, Explorer IV is installed on the top of a JUPITER-C rocket. Dr. William Pickering (*left*), JPL scientist, is flanked by George Ludwig (*center*) of the University of Iowa, and Charles Cole (*right*) of JPL. In the foreground are D. Trimble and D. Huls, both of whom are members of the JPL staff.

Instrumentation is more advanced and specialized, and is devoted to the investigation of corpuscular radiation at extreme altitudes and latitudes. In the picture at the upper right of this page, the guidance mechanism is being examined by J. O. Jennings in checking out the JUPITER-C prior to shipment from the Redstone Arsenal, Ala., to the Cape Canaveral, Fla., site. The Explorer IV undergoes still another test in the picture at the lower left-hand side of the page as R. M. Christmann stands by at the environmental test chamber. The photograph at the lower right of the page shows the satellite being mounted on a vibration table by Lee Ramsey for another phase of the exhaustive testing process.

Within the Army, the project was undertaken jointly by the Army Ballistic Missile Agency (ABMA), the Redstone Arsenal, and the Army's Jet Propulsion Laboratory (JPL), located at Pasadena, Calif., both of which are elements of the Army Ordnance Missile Command, which is headquartered at Redstone.

The latest satellite was launched by a modified JUPITER-C missile, a composite re-entry test vehicle which played a major role in the solution of the aerodynamic re-entry heating problem associated with the JUPITER intermediate range ballistic missile (IRBM) development program. Across the top of the next page is the satellite (*photograph on left*) mounted in a vibration bracket at the Guidance and Control Laboratory of the ABMA where it was assembled. Preparations are made (*photograph on right*) by A. W. Anderson to record the results of a simulated flight of the JUPITER-C rocket. This flight simulation test was the final one to which the rocket was subjected before being transported to the launching site. The main stage of the JUPITER-C is a modified Redstone ballistic missile booster supplied by ABMA; the upper three solid-propellant stages were furnished by the JPL. For the Explorer IV mission, the rocket consumed a high-energy fuel which is known as hydyne. In the main stage, it provides both higher thrust and greater range. Liquid oxygen was utilized as the oxidizer.

The elliptical orbit of Explorer IV, and its total concentration on radiation studies, were prompted by the findings of the earlier Explorer satellites. At the

higher altitudes, they detected high corpuscular radiation intensities that were much greater than those that had been anticipated. The new IGY satellite will continue these investigations. Designed to measure and define this radiation more accurately, scientists at IGY hope to determine its source—whether the particles come from the Sun or from interstellar space beyond.

Photograph on lower left of page was taken during spin test of the completed satellite as Mr. Christmann makes more observations. The payload was added to the fourth-stage motor which is orbiting with the satellite in which four radiation counters are carried instead of the previous one. These counters were especially designed to provide up to many thousand times the accurate counting rate of the other two. As in the case of the previous satellites, the physics department of the State University of Iowa, Iowa City, designed these counters.

Explorer IV carries two radio beacons, both of which are transmitting information continuously to ground stations over common channels. A low-power beacon is transmitting on the 108.00 mc with 10 milliwatts of power. At the same time, a high-power transmitter is operating on the 108.03 mc with 30 milliwatts of power.

To attain the desired orbit, the satellite was launched in a northeasterly direction over the Atlantic Ocean. All previous space vehicles were fired in a southeasterly direction over the Atlantic Ocean test area. Explorer IV is in a highly elliptical orbit and its orbital band covers most of the Earth's surface. Its extremities are the 51st latitudes north and south, compared to the 35 degrees latitudes north and south attained by Explorers I and III. The vehicle traveled over water during the entire launching period. The orbit thus attained assures that the entire United States and the southern portion of Canada will be within the orbital band. The earlier satellites, Explorer I and Explorer III, traveled over only approximately one fourth of the southern part of the United States. The declination of the orbit of Explorer IV against the equator is 50.82 degrees.

The JUPITER-C is launched in a vertical position. It rises slowly at first, then accelerates to several times the speed of sound. Explorer IV is lifted (*photograph at bottom right*) from the Earth as the JUPITER-C rocket blasts off. As it rises, controls cause the missile to tilt into its preplanned trajectory. During the latter stages of ascent, the main power plant is expended and the main stage separates and falls back to Earth. Shortly thereafter, the upper stages reach the apex of trajectory and the second stage is fired. The instrumented compartment of the main stage also separates and falls back to Earth. Firing of the third stage and the fourth stage occurs immediately after burnout of the motors in sequence. The final stage kicks the velocity up to an orbital speed of approximately 18,000 miles per hour.

Upper stages are spin stabilized by electric motors mounted in the main-stage instrument compartment. The upper assembly begins to rotate prior to launching and attains a speed of more than 700 revolutions per minute in flight. Preliminary figures of the satellite's orbit indicate that the Explorer IV completes its circumnavigation of the Earth in 110 minutes and that the perigee is 178 statute miles, whereas the apogee is 1,368 statute miles.

The launching was made possible through the combined efforts of several of the previously mentioned Army organizations, a great number of industrial fabricators and suppliers throughout the United States, and the co-operation of the U.S. Navy and of the U.S. Air Force.

The satellite project was carried out under the direction of ARPA and the Army Ordnance Missile Command, which is under the guidance of Maj. Gen. J. B. Medaris. Work at ABMA in providing the main stage of the missile and its operating systems involved all 10 laboratories of the Development Operations Division under Dr. Wernher von Braun. The launching missile underwent certain modifications and was tested prior to shipment to Cape Canaveral.

ELECTRICAL ENGINEERING EDUCATION

AIEE in University of Akron

LOCATED in the heart of an Ohio industrial area, the University of Akron combines its College of Engineering curricula of developing fundamental classroom principles with actual practice in the nearby factories and industries through a 5-year co-operative plan.

Established in 1914, the College of Engineering has three divisions, electrical, mechanical, and civil. The Student Branch of the AIEE was organized on October 15, 1926. Present counselor for the Branch is K. F. Sibila, head of the department of electrical engineering.

Ayer Hall (right), one of the newer buildings on the campus, is named for the late Dr. Fred E. Ayer, first dean of the College of Engineering and a pioneer in co-operative engineering education. He served for 33 years before retiring in 1947.

Courtesy Tobias Studio

The AIEE Student Branch: A Co-Curricular Activity

L. F. HICKERNELL
PRESIDENT AIEE

CURRENTLY, there are 334 organization units in the Institute. Comprising this number are 157 Student Branches, 113 Sections, and 64 Subsections. To visit all of these in one year would be impossible, even theoretically.

Accordingly, I welcome this opportunity to meet with the Counselors and Student Branch Chairmen of Districts 8 and 9 at this 1958 Pacific General Meeting. As you know, AIEE meets at least once each year on the Pacific Coast. If the annual Summer Meeting is held in the East in June, this Pacific General Meeting is held alternately in the North and South in August. You are fortunate in that this schedule provides you and your national officers with an opportunity to meet and plan your program for the next administrative year in the atmosphere of, and as a part of, a major assembly of the Institute.

75th Year Begins

I sincerely hope that you will make the most of this unique opportunity to fulfill the obligations won when you were elected Student Branch Chairmen by the fellows back home. You are here to plan your program of action for the coming college year. What you decide here, and how you apply those decisions on the campuses, will determine AIEE's role in the colleges of our two great Pacific Coast Districts in this, the Institute's 75th Anniversary year.

During 1957-58, there were 157 Branches, which held 1,374 meetings with a combined attendance of 87,477. This Branch organization along with its 10,000 members is larger, covers more territory, and has greater meeting attendance than many engineering societies in the world. You Branch Chairmen have a big job to do. When we add the 52,000 graduate members, with their 112 Sections, 67 Subsections, and 223 Technical Groups, holding 2,606 meetings attended by 137,373 folks, the Vice-Presidents have a big job, too. Mr. Gustafson already knows this; Mr. Nelson, starting his 2-year term, will soon find out!

The "Line" Organization

At this Conference is assembled one of the complete "line" organizations of the Institute; Branch Chairman to Vice-President to President. For the moment, you can forget about the 52,000 graduate members; they only do a lot of hard work and pay the bills! Incidentally, the bill for student activities is no small item. It amounted to approximately $100,000 last year.

L. F. Hickernell

Fortunately, the "line" organization to which I referred has the help and guidance of a "general staff." First, and most important, the Branch Chairman has his Counselor. The Counselor is a member of the District Student Activities Committee which, in turn, is represented on the Institute Student Branches Committee. These Committees continually study and improve the Branch operations.

The Branch creates an opportunity to gain experience as necessary to your professional and business life as technology. You must learn to co-operate, to compromise, to lead and serve, to talk and debate,

Full text of an address presented at the Student Activities Meeting during the AIEE Pacific General Meeting, Sacramento, Calif., August 19-22, 1958.

L. F. Hickernell is with the Anaconda Wire and Cable Company, Hastings on Hudson, N. Y.

to accept defeat and accomplishment gracefully. Parliamentary experience, too, will come in handy some day. For the Branches to be effective, these opportunities must be available to all; from freshmen to seniors. It is the duty of the officers to see that as many members as possible are engaged in Branch work. In any organization, you get out of it as much as you put into it.

Program Suggestions

Insofar as practicable, I would suggest that programs be created from local talent on the campus, or from nearby Sections. As a member of the Prize Awards Committee, I took part in the struggle to select the "best" paper from 20 or so, and wondered at the time why the Branches resort to outside speakers at all. Of course, these papers were the winners of District competitions. But, if papers have to be that good to win, I wouldn't mind listening to some of the losers—the runners up, at least.

Some of the speakers from nearby Sections may not be polished lecturers, but their practical experience may be well worth absorbing. Developing a "listening skill" is more important to your career than being entertained for an hour or so by a witty speaker. Note-taking, too, is an an art well worth cultivating. Taking notes is a good way to absorb the pith in what even a poor elocutionist says: and you may be surprised how valuable your notes will be some day. In my office, I have on file notes which I have taken for more than 12 years, in the classroom and at technical and committee meetings. If forced to choose, I would prefer to retain my notes file over any other to which I have access.

Discussion Lends Interest

Meetings are more interesting and valuable if papers are followed by intelligent discussion. If the speaker is a recognized authority, he probably has written papers on his subject. Nothing would be more complimentary and inspiring to him than to have some questions from the floor based on his own writings. This, of course, requires thought and planning; but it also generates more member participation.

The conventional paper-and-discussion program can be varied profitably, upon occasion, by arranging a panel of three or four discussion leaders. After a 10-minute informal presentation on different phases of a subject, discussion can be invited from the floor, and probably will take place among members of the panel.

No doubt you will have financial troubles in operating your Branches. I hope you do. You are almost sure to in later life—be it in AIEE, in church, in business or, more surely, at home. Operating on a limited budget will provide training of lasting benefit. Any darn fool can run anything if he has unlimited funds. Real leadership is exercised in making one dollar do the work of two.

Kinship to Sections

I cannot urge too strongly a close relationship between the Sections and Branches in a community or area. They are two very vital components of the Institute organization. They have much in common, because they are directly in contact with the individual members who, in the final analysis, are the Institute itself. Close co-operation should exist between Branch and Section Chairmen. If necessary, I would suggest that the Branch Chairmen and Counselors take the initiative. Perhaps the Section Chairman may feel that overtures by him would be construed as interference in your affairs.

We have lots of active working members in AIEE. In addition to the Executive Committees of the Branches, Sections, and Districts, there are 3,000 members serving in the Departments, General Committees, Divisions, and in Technical Committees.

We "Do It Ourselves"

We are a "do-it-yourself" organization. The Institute is managed, supervised, and operated by members. Its finances are handled by members. Its articles and papers are written and reviewed by members. Its publication policy is determined by members. When enough members of AIEE want something, they get busy and get it for themselves.

When a prospective member asks, "What do I get out of it," you can give him an impressive list, and assure him it is a bargain, too. But, if his interest is limited to "What can I get out of it," he is not yet ready for membership.

When a man joins AIEE, he doesn't "buy" a service, or a magazine subscription, or a ticket of admission to a meeting. He joins a distinguished professional organization, formed by such men as Bell, Edison, Sperry, Thomson, and Weston. The 71 charter members, as have electrical engineers ever since, found in the Institute an opportunity to share their talents, knowledge, and experience in advancing the art and science of electrical engineering—to create more so that all may have more, to do together the things one cannot do by or for himself.

Opportunity and Responsibility

For most of the officers and committee chairmen, the Institute is a second career. It is hard work, as is anything worth while. Although different from a bread-and-butter job, it is equally rewarding, not only professionally, but also socially. In graduate years, you will find that some of your best personal friends are gained through AIEE contact.

In all sincerity, I believe that from the standpoint of your career, the Institute office of Branch Chairman may properly be viewed as your most important activity next to engineering courses. Do not consider your Branch work as just another "extra curricular" activity; it is "co-curricular," and as much a part of your education as any course you take, more valuable than some.

Before the administrative year of 1958-59 has ended, the Institute will have completed its 75th year. We officers of 1958-59 are privileged to guide it past a significant marker on its course. With privilege, inseparably, comes responsibility in equal measure.

Each of us has responsibilities commensurate with our experience. Through co-operation and hard work, I am sure we will be able to discharge them to the benefit of the Institute and to the members of the profession which it serves.

Electrical Engineering Education

Introducing Young Engineers to Magnetic Amplifier Problems

L. A. FINZI
MEMBER AIEE

YOUNG ENGINEERS entering a field of electrical development and design seldom possess an adequate perspective of the phenomena and facts and methods that are pertinent to that area. In fact, they may have altogether immature notions of the ways by which engineering problems are solved. This is particularly true if their college training has been of a dreary "learning by the book" variety, where procedures and "formulas" may have been derived or accepted without adequate efforts to appreciate their physical significance, limitations, and implications and where so-called problems really may not have extended beyond disguised pretexts for algebraic or arithmetic manipulations within the rigid frame of those formulas.

In many cases, the young apprentice has the assistance of dependable elements of experience, expressed by company files and collections of test results on earlier products and by the advice offered by senior colleagues on the job. This body of knowledge is not to be considered as unassailable and final, but certainly is useful for bringing the problems at hand within the grasp of the beginner. The situation is more difficult in newer fields.

A special article recommended by the AIEE Educational Publications Committee.

L. A. Finzi is Buhl professor of electrical engineering, Carnegie Institute of Technology, Pittsburgh, Pa.

Electrical Engineering Education

such as the rapidly moving field of nonlinear magnetic devices.

Magnetic amplifiers are deceptively simple devices in their structures and in their essential circuitries. It is not difficult to acquire some notion of their general operation in a qualitative way, and the design of the components is initiated with considerations that are not different from those of small transformer design. But the further reduction to practice presents the beginner with a variety of unforeseen difficulties. The technical literature is abundant, but seldom is written for tutorial purposes. The most important properties of the materials are unsuspectedly elusive, and the different approaches introduced to fit different problems seem dubiously inconsistent at first. In addition, newer fields seem characterized by a greater haste, with the hectic shifting of engineers from company to company or from task to task within one company, and it may often be necessary for the beginner to rise to mature responsibilities quickly and without much assistance.

Under these conditions, magnetic amplifiers are being built successfully, meeting stringent specifications with a wealth of clever ideas, but the process remains quite expensive in terms of engineering man-hours. Hence, a practical need is felt in industry for some form of training that may save some of the time that the young engineers spend in searching their own ways and learning from their own mistakes.

It is suggested here that a constructive training should not be conceived as a teaching of special technologies for special tasks. Factual information and manuals of design, etc., are most useful in competent hands but are not, in themselves, the way to attain competence. Too many effects are not yet clear in this field, and experimental approaches still are the mainstay of the art. The empirical approach is fruitful if guided by a physical insight of what to look for and by a critical, almost sophisticated, attitude in the interpretation of the experimental results. And the same keen habits of thought are needed in the choice of methods of attack and assumptions in the analysis. Inasmuch as these abilities are not acquired on the spur of the moment, the training in question should aim at their development.

In addition, the exploitation of the unusual features of modern magnetic materials is not limited to conventional magnetic amplifiers, and new applications are being disclosed continuously. The principles of operation and the associated problems of design are quite similar in all cases; a schooling by fundamentals is essential to bring about fully a unified understanding and also to stimulate further inventiveness.

The Quest for Simplicity

It is agreed that simplicity should characterize the educational effort. However, there are pitfalls associated with the desire for simplicity, as any teacher well knows when facing the dilemma of what to say and what to leave unsaid to the student. No one would seriously suggest that the beginner should be presented at once with all the complexities and elusive effects which may well emerge significantly in his future work. But analogies and explanations that are farfetched or overly simplified are not a constructive approach either. For instance, the concept that the magnetic amplifier is a sort of "reactance" is not immediately called for, since coils wound on cores of a "square loop" magnetic material really do not possess any one of the properties inherent to the concept of inductance. The beginner, who by definition does not know any better, is bound to be literal-minded; moreover, his background in the matter of magnetic circuits may be already anchored too much on sophomoric treatments unwilling to depart from linear or linearized procedures (with hysteresis loops thrown in none too clearly as a matter of curiosity). Therefore, it may be deemed necessary early in his training to shock him into different ways of thinking which are more pertinent in many problems of modern nonlinear magnetic devices.

Forms of simplicity that are educationally questionable are also those in which a comparatively complicated system is made simple by the precipitate introduction of extreme idealizations (cores with zero and infinite permeability, circuits with zero resistance, etc.). Such treatments may describe certain interesting patterns of behavior quite skillfully, but strong reservations are voiced here in principle against the *postulation* of assumptions and against the immediate use of reasonings by *limiting cases* in the educational approach without careful and reasoned justification. The beginner is not in the position to appreciate what the assumptions really stand for and can only accept those methods passively. Soon enough, however, he may sense that those assumptions and approaches are neither adequate nor useful in many of his problems. A search for better procedures may be difficult at this point if exceedingly simplified ways of thinking have been already ingrained in his mind.

The approach suggested in the following is one in which simplicity is sought in a different manner. Namely a physical system is considered first which is comparatively simple in itself, i.e., a core with some windings. A fascinating wealth of meaningful problems can be found already at this level in applications of practical interest. No simplifying assumptions are postulated a priori. Rather, the properties of actual components (cores, rectifiers, etc.) are considered, as known from the recent technical literature and recognized by experimentation, and the essential meanings of the fundamental laws expressed in the system equations are examined. Instances and problems can be chosen gradually and in a proper sequence so that plausible idealizations and simplifications—extreme as they may be—might suggest themselves to the student as needed in any specific problem, avoiding confusion of issues and unwarranted extensions to different situations. A transition to more complex multicore systems can evolve further coherently.

An Example of Course Organization

A summary of course organization has been proposed elsewhere.[3] Space limitations compel here to a further condensation, which, it is hoped, may remain sufficient to illustrate the argument, merely as an example of what can be done.

It is assumed that the student has been exposed to sophomoric concepts of electromagnetism. Such concepts really are sufficient to handle the simple magnetic structures of the magnetic amplifier, but earlier exposures may not have been adequate for a full appreciation of the meanings of the basic laws. Hence, the implications of Kirchhoff's voltage law applied to a simple loop containing a toroidal winding on a core of an arbitrary material may be reviewed first. Concepts of flux densities, fluxes, and flux linkages are discussed, and the concept of the volt–time integral and the "principle of nonrectification" are introduced. Faraday's law and Ampere's circuital law are not sufficient in nonlinear problems: the "missing link" to relate currents and fluxes is recognized as the main hurdle that shall be met and surmounted later in various manners.

The properties of square-loop cores are expressed well enough at this point by the information exhibited in core catalogs and by oscilloscopic displays of hysteresis loops and of waveforms of magnetizing currents. Three essential features are seen (1) in the sharply defined "saturation," (2) in the pronounced hysteresis, by which the core flux remains "set" at any reached level upon removal of the magnetomotive force, and (3) in the comparatively small field intensities in flux excursions over the unsaturated range. (From the "dynamic" loops of the catalogs it appears already that the mmf depends not only on the flux but also on the flux rates: some cautious explanation in terms of "eddy current" may be given temporarily for this.)

Feature (1) leads to the definition of the "core volt–time area" and of the "normal" excitation. Instances are offered by certain voltage references and transistorized inverters, by 3-phase to single-phase schemes of frequency trebling, and by peak-transformer-type pulse generators. Feature (2) is used in certain pulse counters and time-delay devices. The idea that a flux level ϕ_p can be "preset" by a signal to determine the future behavior of the system leads to the introduction of the half-wave amplifier. The presetting by signal voltages directly applied to the core is readily understood in the elementary Ramey circuit, and the thyratron-like behavior of the output circuit of magnetic amplifiers can be explored then, in conjunction, for resistive and resistive–inductive loads. Multicore combinations of that amplifier can also be examined, recognizing the galvanic coupling through the common load. The discharge of a capaci-

tor in series with a linear inductance and a square-loop reactor is another interesting example which can lead to the explanation of possible subharmonics in periodic operation.

The instances mentioned have used feature (3) only to justify "ideal core" assumptions. The half-wave circuit controlled by a variable resistor across the self-saturation diode brings the matter of magnetomotive forces in a more evident light; the voltage that controls the amplifier here is the voltage drop of magnetizing currents through that resistor, hence some notice must be taken of those currents. A transfer characteristic can be predicted, for instance, at high outputs from the information given by the static hysteresis, while at low outputs a dynamic major loop is more pertinent. This reasoning, although rough, is not deprived of a practical sense and accounts for, rather than ignores, essential phenomena. The student may discover for himself the core-test procedures that would be needed if more accurate predictions were necessary. In this manner, empiricism is introduced on a reasoned basis. Many other applications can be found in square-loop circuits, transistorized or not, which perform logic or analytic operations.

The half-wave amplifier controlled from a current source leads to the study of the dynamic processes of flux reversal under the action of an applied constant magnetomotive force. Core-reset functions, relating in some approximate form the instantaneous values of mmf's, fluxes, and flux rates, can be introduced and used in simple problems of memory-core switching and shift registers and multiaperture components of computers. The "back-firing" of rectifiers can be recognized and explained in the half-wave amplifier. The biased-rectifier amplifier and many half-wave push-pull circuits with high control-circuit impedance are further instances of this type of "current source" control. To clinch the matter of "voltage control" versus "current control," a circuit has been presented[1] in which the one or the other approach is dictated, quite evidently, by the different situations that occur in its use as a "fast response" component of a multistage system or as a "low level" amplifier.

Industrial core-testing methods are described then, discussing the meaning and possible uses of the results, presented as core-control curves, or dynamic permeabilities or dynamic core resistances. This leads to the study of conventional doublers and center-tap and bridge circuits, unless one prefers to postpone this study to that of the two-core saturable reactor. The classical approach to the saturable reactor with "zero control resistance" and "ideal cores" can be used as a welcome simplification of a problem, stated initially in its more general terms; for this, it may be suitable to start from the opposite case of the d-c current transformer (i.e. the "infinite control resistance"). The use of a square-waved supply voltage in conjunction with a pure d-c signal voltage may be considered, to avoid the tediousness of the solution of transcendental equations in the general case.

Simple instances of feedback, magnetic or galvanic, can be shown and analyzed, as applied, for example, to a conventional bridge amplifier, and the features of "voltage-balance" type amplifiers can be discussed. The problem of transient response can be attacked first with the time-honored "slow transient" approach in which half-cylic averages of currents and voltages and preset flux levels are approximated with continuous time functions. This approach leads to interesting results, as the time constant obtained is proportional to the voltage gain, regardless of feedbacks in a first approximation, and a dynamic power gain can be defined which is proportional to the current gain. The flip-flop mechanism of bistable amplifiers also can be studied. More exacting question of fast response and phase shifts require the use of difference equations, which, however, are of an extremely simple form and can be handled consistently with techniques that are quite similar to those of ordinary differential equations of the first order, with very interesting results.

Push-pull, polyphase, and multistage combinations remain to be examined. Many elusive effects already met by the student in the operation of simple single-ended amplifiers appear with increased complexity in these combinations. The descriptions and the semiqualitative considerations of design found in the literature are a good starting point for a reduction to practice. The designer is on his own from there. It is not within the scope of the training to supply quick answers to problems as yet unsolved, but rather, more basically, to equip the individual with the insight that is needed for further development work, experimental and analytical.

Conclusion

The outline presented in the foregoing is not complete and is far from unique. Different instances and problems and also a different balance of content can attain the same aims with the same basic point of view. The point made is that a clarification of the physical law and phenomena, and a good appreciation of the essential properties of the components are the prerequisite of any technological design. Many subtle issues cannot be avoided, which conceivably one would prefer to ignore or hide, but which unfortunately remain of primary concern for anything better than vague and qualitative descriptions. Such issues are abundant in this field. The constructive way to go about facing these issues is to introduce simple instances in a coherent sequence so as to stress a few concepts and methods at the time, with a discriminating appraisal of the simplifying assumptions that may be introduced, as a calculated risk, in the various cases.

Lectures to a passive audience should be avoided; information passively acquired can seldom be put to use and might result rather in a dangerous acceptance of ill-digested half-truths when novel and unconventional concepts are unfolded. Many of the instances can be presented as problems, with the assistance of a few restrained hints, leaving it to the students to search for suitable approaches with the help of some simple experimentations as needed, and then co-ordinating their findings in a more general perspective. In other instances, the students can be invited to establish critical comparisons of the content of technical papers describing devices unrelated perhaps from the point of view of applications but embodying some essential common feature. Caution is needed, however, in the timing and co-ordination of this suggested reading, because of the extreme ease with which misconceptions arise in the beginner's mind.

It is suggested that the habit be formed of spelling out the circuit equations, with consistent symbols and conventions, from the start, simply because this is the most convenient and compact way to express the physical laws. Even when it is found that the solution of these equations may be cumbersome or practically impossible, their judicious consideration and reconsideration at all steps constitutes a valuable guidance in partial predictions, in the interpretation of empirical findings, and in extrapolations by similitude.

Practically, one dozen problems, distributed over about as many weeks and solved with the support of a weekly half-day laboratory session and a two-hour class meeting, have proved sufficient in recent graduate courses at the Carnegie Institute of Technology to cover the area described. The results seemed quite good, as evidenced by the many original thoughts that were stimulated, with germs of ideas of the kind that may evolve into technical papers or patent disclosures. It was noted that students who approached this peculiar field with open minds, considering magnetic amplifiers as electromagnetic systems that obey the general laws of electromagnetism with particular twists dictated by the special properties of the components, did not have serious conceptual difficulties at any time. This was not the case, initially, for students who had previous misconceptions and biased points of view acquired from the casual reading of technical papers chosen at random or also from unwarranted generalizations of some narrow and hasty experience.

The same general approach has been tried also in industry. In the case of groups of engineers, familiar or not with the magnetic amplifier proper, but conversant with questions of electromagnetic development and design, the pace and the attitude were somewhat modified; but still the presentation of problems and their informal discussion remained the most fruitful part of every session.

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Reference

1. Introducing Young Engineers to the Appreciation of Magnetic Amplifier Problems, L. A. Finzi. AIEE *Communication and Electronics*, Mar. 1958, pp. 119-26.

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R. M. Hermes Appointed to ECPD Accreditation Committee

Dr. R. M. Hermes has been appointed vice-chairman for the Western States of the Education and Accreditation Committee of the Engineers' Council for Professional Development (ECPD). This ECPD Committee is the national unit for accrediting undergraduate engineering colleges.

Dr. Hermes, manager of the Stanford Research Institute (SRI) Control Systems Laboratory, at present is on special assignment. He is directing SRI's instrumentation work for the Combat Development Experimentation Center at Ford Ord, Calif. SRI is providing scientific support for the Center, under contract with the U.S. Army.

ECPD is comprised of one Canadian and seven United States engineering societies.

Simplicity in 3-Phase System Circuit Conventions and Concepts

W. A. LEWIS
FELLOW AIEE

Part II

Circuit Diagram for a Polyphase Generator

It is very helpful in many types of circuits to arrange the circuit symbols in a pattern that suggests either the physical arrangement or the arrangement of the phasors, or possibly both. This is usually particularly helpful in showing the circuits of a polyphase machine, where the windings themselves are symmetrically arranged in the stator and the voltages are equally displaced. A typical case for a 3-phase generator is shown in Fig. 3.

If rotation of the rotating field member is chosen as clockwise, then the windings will have the same relative physical arrangement as the phasors, in order that the rotating field will approach the windings in the desired order, and produce phase voltages of phase sequence *a*, *b*, *c*, as represented by the phasor diagram of Fig. 2. The arrangement shown in Fig. 3 is completely consistent with the phasor diagram of Fig. 2, and is definitely simpler and less confusing than if rotation of the rotor is selected as counterclockwise, so that the order of the phases in the circuit diagram must be opposite to the order of phasors in the phasor diagram.

The adoption of counterclockwise rotation of phasors as the forward direction has suggested to several that forward rotation of the field in a conventional diagram also should be counterclockwise. It should be pointed out that the essential feature for generator action is relative motion between field and armature. The first generators had stationary fields and rotating armatures, but the present practice of rotating fields is now universal except for the smallest generators. If the field rotates clockwise, the rotation of the armature, relative to the field, is counterclockwise. If the field were stationary, the armature would have to revolve counterclockwise to produce the same relative relation. Yet the same phasor diagram would apply to both.

Accordingly, the standard rotation may be interpreted as the relative motion of the armature with respect to the field, and this is achieved in a conventional rotating-field machine by clockwise rotation of the field.

For an actual physical machine, the direction of rotation may be specified, but this must include a statement as to which end of the shaft is being viewed when the rotation is stated. Obviously, any statement of direction of rotation as viewed from one end of the shaft is reversed when the same machine is viewed from the other end. Thus, as far as a general diagram for theoretical purposes is concerned, the machine may be viewed from either end, and the actual physical direction of rotation should play no part in establishing a general convention.

In view of these comments, it is recommended that, in a general machine diagram, the rotation of the field be indicated as clockwise, as shown in Fig. 3, in order that the circuit diagram may be arranged in the same order as the corresponding phasor diagram.

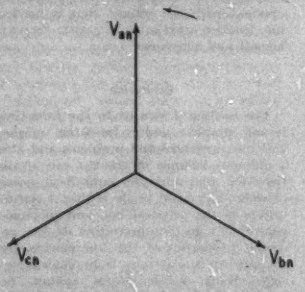

Fig. 2. Voltage phasors for a 3-phase system.

Desirable Conventions for Synchronous Machine Analysis

With regard to the synchronous generator, it is desirable that the most convenient conventions be established, so that the analysis may be as simple as possible. If each phase is treated as a portion of a circuit loop, from phase to neutral, then the current reference direction in each phase and the voltage reference polarity should be assigned consistently, in accordance with earlier sections. For the generator itself, it is appropriate that these be assigned for the generator portion of the loop, which requires that the reference current direction shall be out from each phase, as shown in Fig. 3, and that each phase terminal shall be the positive terminal, with the neutral as the common reference, as shown.

It is also desirable that the field reference current direction be chosen as the direction of normal current, so that the

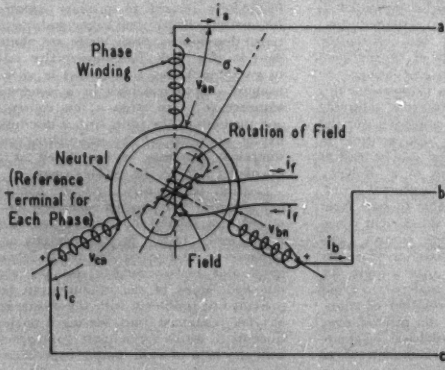

Fig. 3. Synchronous machine circuit diagram.

Part II of a 3-part article recommended for publication by the AIEE Educational Publications Committee. Part III is scheduled for publication in the December 1958 issue of *Electrical Engineering*.

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normal unidirectional field current will be positive.

The mutual inductance between the field and each armature phase is a variable, depending on rotor position. For an ideal machine, it varies as the cosine of the angle between the axis of the field and the axis of the phase concerned, and for a practical machine of good design, it is so close to such a relationship that it may be assumed to vary in that way. Then the mutual inductance between the field and phase a, selected as the reference phase, may be written

$$L_{af} = L_{afM} \cos \sigma \tag{6}$$

where σ is the angle between the axis of the field and the axis of phase a, as shown in Fig. 3, measured positively in the clockwise direction from the axis of phase a, and L_{afM} is the maximum value of L_{af}, assumed positive. It is tacitly assumed in equation 6 that L_{af} is positive when σ lies between $-\pi/2$ and $\pi/2$. The opposite may, of course, be assumed by the introduction of a minus sign in equation 6, but offers no advantage, since L_{af} will be negative during half the revolution anyway, because of the cyclic variation of $\cos \sigma$.

At no load, when the armature currents are zero, the flux linkages of each phase result only from the field current. The flux linkages of phase a become

$$\lambda_{ga} = \pm L_{af} i_f = L_{afM} i_f \cos \sigma \tag{7}$$

From the standpoint of simplicity, it seems most desirable that the flux linkages of the armature phase should be taken as positive when the axis of the phase and the axis of the field coincide, that is, when $\sigma = 0$. This will result if the upper sign is chosen, and then, by convention, the flux linkages of phase a, resulting from the field current alone, become

$$\lambda_{ga} = L_{afM} i_f \cos \sigma \tag{8}$$

Since the generator portion of the loop is being considered, the no-load voltage is given by equation 3, and it becomes

$$p_{an} = -\frac{d\lambda_{ga}}{dt} = L_{afM} i_f \sin \sigma \frac{d\sigma}{dt} \tag{9}$$

Under normal operation $d\sigma/dt$ is a positive constant angular velocity ω.

It is necessary to verify that this choice is satisfactory by checking it against known operating requirements. It is known from physical considerations that if the generator current leads the no-load voltage, the effect of the generator current will augment the effect of the field current, and increase the flux linkages. A current which leads the voltage by the maximum phase angle, that is, for zero power factor lead, is given by

$$\begin{aligned} i_a &= \sqrt{2}\ |I_a|\ \sin\left(\sigma + \frac{\pi}{2}\right) \\ &= \sqrt{2}\ |I_a| \cos \sigma \end{aligned} \tag{10}$$

When this quantity is positive, its contribution to the flux linkages of phase a is positive, and if the contribution from the field current, given by equation 8, is also positive, the positive sign should be used in writing the combined flux-linkage expression. It readily can be seen that equations 9 and 10 are positive for the same values of σ and, therefore, the use of the plus sign is appropriate.

The relations between the flux components will also be satisfied if the negative sign is selected for the mutual inductance term of the flux linkages, because both the terminal voltage and the armature current depend upon the flux linkages caused by the field current, and will reverse in sign also. However, in that case, the flux linkages of phase a are negative at the instant when the field and the phase are in line. This would be the result of winding the coils in opposite directions. Such a choice is awkward and hardly would be selected if a free choice were being made in a general analysis.

The three phases also are coupled among themselves. From Fig. 3, as well as from physical considerations, it may be seen that current in the positive direction in one phase partly opposes the effect of current in the positive direction in each of the other phases. This effect may be represented by using a negative value for the mutual inductance and a plus sign preceding these mutual terms, or a positive value for the mutual inductance and a negative sign for the mutual terms. There is little to choose from in this case; both methods are used, and the important point is to see that whichever method is used, it is used consistently. To be definite in this analysis, it will be assumed that the mutual inductances are negative, and the mutual flux-linkage terms will then be preceded by plus signs.

The self-inductances of the armature phases and the mutual inductances between phases are approximately constant in nonsalient-pole machines for a uniform degree of saturation, but in salient-pole machines they are variable, as a function of rotor position. They may be represented reasonably accurately by a constant term, which has the same value for the three self-inductances and another constant value for the three mutual inductances between any two phases, plus a second harmonic function of the rotor angle. The coefficient of the second-harmonic term has the same value for both the self-inductances and the mutual inductances. The explanation is given in treatments of the analytic theory of synchronous machines.[5] Assuming this form of variation gives

$$\begin{aligned} L_{gaa} &= L_{aa} + L_{a2} \cos 2\sigma \\ L_{gbb} &= L_{aa} + L_{a2} \cos\left(2\sigma - \frac{4\pi}{3}\right) \\ L_{gcc} &= L_{aa} + L_{a2} \cos\left(2\sigma - \frac{2\pi}{3}\right) \\ L_{gab} &= -L_{ma} + L_{a2} \cos\left(2\sigma - \frac{2\pi}{3}\right) \\ L_{gbc} &= -L_{ma} + L_{a2} \cos 2\sigma \\ L_{gca} &= -L_{ma} + L_{a2} \cos\left(2\sigma - \frac{4\pi}{3}\right) \end{aligned} \tag{11}$$

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when the appropriate functions of rotor position are introduced in the most convenient form.

Using the conventions and assumptions described leads to the following expressions for the flux linkages of the windings of an elementary synchronous generator. In addition, a practical generator may have several amortisseur or damper circuits on the rotor, which normally carry no current during normal or steady-state operation. However, their effects must be included in any transient analysis. For the purpose of developing desirable conventions, they are not needed, and will be omitted here. The results are

$$\begin{aligned} \lambda_{ga} &= L_{gaa} i_a + L_{gab} i_b + L_{gca}\, i_c + L_{af} i_f \\ &= L_{aa} i_a - L_{ma}\,(i_b + i_c) + L_{afM} i_f \cos \sigma \\ &\quad + L_{a2}\left[i_a \cos 2\sigma + i_b \cos\left(2\sigma - \frac{2\pi}{3}\right)\right. \\ &\quad \left. + i_c \cos\left(2\sigma - \frac{4\pi}{3}\right)\right] \\ \lambda_{gb} &= L_{gab} i_a + L_{gbb} i_b + L_{gbc} i_c + L_{bf} i_f \\ &= L_{aa} i_b - L_{ma}\,(i_c + i_a) \\ &\quad + L_{afM} i_f \cos\left(\sigma - \frac{2\pi}{3}\right) \\ &\quad + L_{a2}\left[i_a \cos\left(2\sigma - \frac{2\pi}{3}\right)\right. \\ &\quad \left. + i_b \cos\left(2\sigma - \frac{4\pi}{3}\right) + i_c \cos 2\sigma\right] \\ \lambda_{gc} &= L_{gca} i_a + L_{gbc} i_b + L_{gcc} i_c + L_{cf} i_f \\ &= L_{aa} i_c - L_{ma}\,(i_a + i_b) \\ &\quad + L_{afM} i_f \cos\left(\sigma - \frac{4\pi}{3}\right) \\ &\quad + L_{a2}\left[i_a \cos\left(2\sigma - \frac{4\pi}{3}\right)\right. \\ &\quad \left. + i_b \cos 2\sigma + i_c \cos\left(2\sigma - \frac{2\pi}{3}\right)\right] \\ \lambda_f &= L_{afM}\left[i_a \cos \sigma + i_b \cos\left(\sigma - \frac{2\pi}{3}\right)\right. \\ &\quad \left. + i_c \cos\left(\sigma - \frac{4\pi}{3}\right)\right] + L_{ff} i_f \end{aligned} \tag{12}$$

For the analysis of a synchronous motor, in the load or motor portion of the circuit, the conventions are similar, except that the reference direction of each armature current relative to the reference polarity of the terminal voltage will be reversed. However, any change resulting

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from this difference is compensated by the fact that the inductive voltage is given by equation 4, instead of equation 3. For a motor, the reference arrows on the phase circuits of Fig. 3 would be reversed.

A troublesome question arises with regard to the reference direction for the field current, denoted by i_f in Fig. 3. If the reference direction of the field current is also reversed for motor operation, no change will be required in flux-linkage equations 12, except that the symbols now apply to the motor instead of the generator, and m should replace g wherever it occurs as a subscript in these equations. However, if this change in reference direction of i_f is made, the normal value of i_f for synchronous motor operation would be negative. This results from the fact that the actual field current will normally be directed in the same direction whether the machine is operating as a generator or as a synchronous motor, but reversing the reference direction will change the sign of that current.

If the reference direction of the field current is not changed for motor conditions, then the field current and armature current will oppose each other when both are positive, and the signs of the mutual terms between the field circuit and each armature circuit, shown positive in equations 12, will be changed to minus.

For the analysis of starting performance, when the field is not excited, but is usually short-circuited either directly or through an external resistance, the field current is induced by the armature current, rather than being the result of voltage applied to the field from the exciter. The currents in any damper circuits present are also the result of induction by the armature currents, since these circuits are short-circuited and any currents present in them in any case are the result of induction from other circuits. For such conditions, the simplest equations will result if the reference directions of all currents are reversed when changing from generator operation to motor operation. Thus, in Fig. 3, this recommendation suggests that the reference directions not only of the armature currents but also of the field current and any damper currents involved, be reversed from those shown in the figure when the circuit is being established for a synchronous motor. With those conventions, armature circuits and rotor circuits are considered as aiding when writing flux-linkage equations, and the signs of mutual terms would be assigned accordingly.

Because a great deal of the analysis of motor circuits involves starting performance, it seems preferable to establish conventions most suitable for that operation, and then consider that the field current is negative for synchronous operation with field excited. In this way, uniform conventions would be used for all motor-circuit analysis, and the only special feature would be that the field current of a synchronous motor operating normally would have a negative value.

Reference

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An Electrical Engineer in Industry

KEVIN FRIEDRICH (AM '55), design engineer, Westinghouse Electric Corporation, Sharon, Pa.

"A booming aluminum industry is demanding ever-increasing blocks of direct-current power to satisfy the growing appetite for aluminum. Rectifier engineers are faced with the need for increased ratings in circuit breakers and ignitron tubes as well as improved rectifier circuits and transformer designs. The AIEE helps me as a transformer design engineer through its publications which reveal the latest thinking of experienced men concerning these and other engineering problems. By attending the local meetings of the AIEE, I have maintained an interest in fields other than those associated with rectifiers. In addition, these meetings have brought me into contact with members engaged in a variety of engineering pursuits."

Mr. Friedrich's experience with rectifiers has been as a design engineer for the Westinghouse Transformer Division. His first year with the company after graduating from Carnegie Institute of Technology was on the Graduate Student Course. During this time, he had engineering assignments in atomic power, large motors, rectifiers, and transformers. He also spent three months as a full-time student in the Westinghouse design school, and has taken graduate courses at the University of Pittsburgh.

Mr. Friedrich has served on the AIEE Industrial Power Rectifiers Committee.

Televised Course In Atomic Age Physics

In a revolutionary attempt to raise the standards of physics teaching in all sections of the United States, a nation-wide college course in Atomic Age Physcis is being televised over the National Broadcasting Company (NBC) network. Planned for two semesters, the course began October 6 and will continue through June 5. Designed primarily for high school science teachers, the program is known as the "Continental Classroom."

The course, offered for credit through the auspices of local colleges and universities, is telecast from 6:30 to 7:00 a.m. (in each time zone) Monday through Friday. This marks the first time in the history of mass communications that a course for college credit has been offered on a nation-wide basis.

The national teacher is Dr. H. E. White, professor and vice-chairman of the department of physics at the University of California in Berkeley. Other internationally known scientists serve as guest lecturers. Dr. White, a physics teacher for more than 30 years, has written five college texts. One of these, "Modern College Physics," is the most widely used book in its field in the United States. In addition to his teaching, Dr. White has served as an international research fellow in Berlin and has directed research for the National Defense Research Committee, the Office of Scientific Research and Development, and the Manhattan Project.

Sponsors of the course include The American Association of Colleges for Teacher Education (AACTE), the Fund for the Advancement of Education, and NBC. Consultants for the series include Dr. Mark Zemansky, chairman of the department of physics at City College of New York (CCNY); Dr. Henry Semat, professor of physics at CCNY; and Dr. V. E. Eaton, professor of physics at Wesleyan University, Middletown, Conn.

Lessons during the first semester are being devoted to those aspects of physics necessary for an understanding of nuclear physics: kinematics, light, dynamics, electricity, magnetism. In the second semester, emphasis will be on nuclear and atomic physics. Not only are demonstrations and experiments an integral part of the course, but television presentations are supplemented by periodic tests, textbook assignments, and out-of-class activities.

Under the direction of Dr. E. P. Adkins, national co-ordinator, local college and university personnel implement the program on their own campuses. Participating colleges and universities may utilize the network program at no cost and may charge regular tuition fees for those registering for credit.

Both educators and scientists have ex-

pressed enthusiasm for the project. "Today is a time in history when the improvement of science education is vital," according to Dr. H. M. Rice, president of the AACTE. "It is also a time when classrooms and teachers are in short supply. By utilizing television—a medium that has proved its educational worth—the practical problems involved in the process of up-dating science teachers are by-passed."

Electrical Engineering Education

Graduate Honors Programs with Industry in E. E. at the University of Pittsburgh

J. F. CALVERT
FELLOW, AIEE

THOSE educational activities, which might be termed graduate honors programs and on which I am qualified to report, all involve the University of Pittsburgh and the Westinghouse Electric Corporation. More specifically, they relate to electrical engineering. I shall report on these, but also speculate to some extent on the future; for I believe that within these programs, there has been maintained a consistent and valuable theme which points the way for the future of the activity.

Joint arrangements between the University of Pittsburgh and Westinghouse were initiated in 1927. Although dampened down by depression and held back by war, the essential arrangements have been in force continuously since that date.

However, for many years prior to 1927, educational work was in progress at the company on a nonacademic basis. It was unique in character and was maintained at what could well be called a high academic level. Since this earlier work profoundly influenced subsequent developments, it needs to be reviewed and understood.

A special article recommended for publication by the AIEE Education and Educational Publications Committees.

J. F. Calvert is professor and head of the electrical engineering department at the University of Pittsburgh.

I shall proceed, therefore, in a chronological order, discussing the developments during the following periods of time: prior to 1927, 1927-1940, 1940-1952, 1952-1955, 1955-1957, 1957-1958.

History

Prior to 1927. For more than a decade of this earlier period, the Westinghouse Electric and Manufacturing Company (as it was then known) operated two full-time schools for students who were selected from among those headed for application, or design, or development and research engineering. In themselves, these two schools, called the engineering school and the design school, were rather like honors programs; although no one seems to have thought of this phrase, since the schools were not yet associated with an engineering college.

The philosophy behind these schools was that of B. G. Lamme, the chief engineer. He emphasized problem solving by both qualitative and quantitative methods.

An engineering school student was selected from a consideration of both undergraduate record and personal interview. The school lasted three months, full time. Each week a new battery of questions was issued, the answers for which might be found in the technical literature or through thought and debate. They were seldom found in direct form within the existing text books. On Saturday morning, an oral examination was conducted by a small group of experts.

Admission to the design school called for final selection by Mr. Lamme, but first the candidate had to secure from him and then work for him a set of unusual problems for which little help toward answers could be found in any available publication. Students spent days to weeks on these problems. The design school lasted six months, full time, and was conducted pretty much on a tutorial basis. The work was rather fundamental: no actual machines were designed.

Tables I and II give further data on these early schools.

1927-1940. Starting in 1927, the University of Pittsburgh accepted "B" grade work in the engineering school and the design school for graduate credit. The University reviewed the scholastic and professional records of those engineers teaching in the engineering and design schools, and appointed graduate lecturers from among these men. Only 15 credits were granted for this 9 months of full-time study. Apparently, this decision was influenced by the desire to have 9 course hours taken at the University and also to have a thesis, evaluated at 6 credits, included within the program. Thus, 30 credits in all were included in the minimum requirements for the M.S. in electrical engineering.

The students were admitted to the graduate school in the normal manner. They applied as individuals and, if they met the published standards, they were admitted; otherwise they were not admitted. The company selected the potential candidates.

This was the start of the first graduate

Table II. The Old Design School about 1926-29

COLLEGE ASSOCIATION:	NONE UNTIL 1927
ADMISSIONS:	MODERATELY SELECTIVE PERHAPS 50% OF THOSE HEADED FOR ENGINEERING WERE TAKEN.
PERIOD OF STUDY:	3 MONTHS FULL-TIME
COURSE CONTENT:	LITERATURE SEARCHES RELATED TO: 1. D.C. MACHINES AND VARIABLE SPEED DRIVE 2. SYNCHRONOUS MACHINES- BALANCED AND UNBALANCED 3. INDUCTION MOTORS 4. TRANSFORMERS 5. RAILWAY EQUIPMENT 6. POWER SYSTEMS 7. INSULATION AND HIGH VOLTAGE 8. REGULATORS
EXAMINATIONS:	ORAL AND ONCE A WEEK

Table I. The Old Engineering School about 1923-29

COLLEGE ASSOCIATIONS:	NONE UNTIL 1927
ADMISSIONS:	QUITE SELECTIVE USING 1. COLLEGE GRADES 2. INTERVIEWS 3. SET OF PROBLEMS TAKING DAYS TO WEEKS TO WORK
PERIOD OF STUDY:	6 MONTHS FULL-TIME
COURSE CONTENT:	1. STEADY STATE FIELDS AND APPLICATIONS FORCES, TORQUES, IRON LOSSES, SATURATION 2. EMFS AND MMFS OF CONVENTIONAL AND SPECIAL WINDINGS 3. REACTANCES 4. HEAT: GENERATION, CONDUCTION, RADIATION, AND TRANSFER AT SURFACES 5. FANS, ALSO FLUID FLOW FOR GASES AND LIQUIDS
EXAMINATIONS:	IRREGULAR, BUT SUPERVISION WAS ALMOST TUTORIAL

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honors program in the short series which I plan to describe. Table III shows certain details of this first program which the department of electrical engineering operated with Westinghouse.

1940-1952. During this period, the engineering school was reduced to ordinary course work and later abandoned. Originally, it had presented a survey of much of the then-known areas of electrical engineering. In later years, this became quite impractical. Other and more quantitative graduate courses were being developed and these gradually filled the space left by the engineering school.

1952-1955. During this period, the so called "design school" underwent a marked change. It was reduced in length to about four months, full time, and became more nearly a study of systems as is suggested by Table IV. The object here was to bring together mechanical and electrical engineers (and others as well) through the study of these newer and rather universally useful concepts. The new work closely paralleled regular evening graduate courses which were open to all qualified graduate students, although the periods of time devoted to different subjects were not identical between the design school and the regular courses.

1955-1957. This period was marked by (1) extensive development as well as revision in the regular evening graduate program, (2) the establishment of the Westinghouse Atomic Power Fellowship program, and (3) the establishment of a new kind of day graduate program.

The evening graduate program for this period is sketched in Table V and will not be discussed further except to say that the courses shown there were available to the honors men along with all other qualified graduate students.

In the winter of 1955, the Westinghouse Atomic Power Fellowship program was established at the University of Pittsburgh. This represents a second and different honors program. Reference should be made to Table VI. Again, students were admitted to the graduate school in the normal way and the candidates for the program were selected by the company. A second design school was operated in parallel with the first. Students on the Atomic Power Program who had successfully completed the design school, moved on to the newly established reactor school. The reactor school carried 14 college credits. (It was a full-time program.) At this time, teachers in the design and reactor schools were drawn both from the college faculty and from the graduate lecture groups.

One feature of the program was that the 14 credits from the reactor school could not be applied to the M.S. program so that the additional course work, the comprehensive examination, and the thesis remained unchanged among the major requirements for the M.S.

However, if a student going through this program is adjudged by the full-time college faculty to be qualified to work toward the Ph.D., then he has at this point 14 credits beyond the M.S. At this juncture, the company allows the successful student one day a week (or the equivalent) for study on campus, and, roughly, the last academic year in full-time residence. The first group (8 or 10 men) arrived in the electrical engineering department in September 1956. Most of them registered for 6 credits in the day program.

Table VII shows some of the measures taken to select honor students and indicates the quality of these men.

When the Atomic Power Fellowship program was set up in 1955, the details of the on-campus course times were not worked out. However, beginning in Fall 1956, electrical engineering, mechanical engineering, and mathematics started offering day courses on a one-day-per-course basis. Thus, each such course meets once a week for the first three periods of the day. The major advantages and the potential disadvantage of this arrangement will be set forth:

1. The commuting time of the fellowship men is kept to a minimum.

2. Our own part-time instructors in electrical engineering, who are also graduate students, number about the same as the fellowship men. Their school needs and teaching commitments can be scheduled without much difficulty.

3. When the University wishes to call upon industry for a highly qualified daytime lecturer, this man's time will be used to best advantage. Thus far, we have not been refused on a request made to such a man and, in fact, have had assistance volunteered.

4. It could be contended that three 50-minute meetings on different days is better than the method used. Actual proof either way would be extremely difficult to obtain. The student enthusiasm for the present arrangement probably would mask any results which a questionnaire could reveal.

1957-1958. In 1957-58, the course content of the design and reactor schools matched certain of the regular courses. A fellowship man takes a given selection of the regular courses, but actually there could be many honors or fellowship programs. Various parts of the Westinghouse Corporation other than the Atomic Power Division are sending men to the day program on the same "day-a-week-or-equivalent" basis. Other companies can do this also. Thus, the graduate honors programs may be almost as varied as desired, yet the university may (and, in view of the manpower limitations, usually would) resist custom built programs involving the expenditure of effort on the development of specialized courses. Some idea of the possibilities for building curricula from the existing courses may be gained from Table VIII.

Table III. Early Program Leading to M. S. (in E.E.) Degree for Honors Students

M.S. (IN E.E.) PROGRAM 1927-40

COLLEGE ASSOCIATION: U. OF PITTSBURGH

ADMISSIONS: INDIVIDUAL APPLICATION TO GRADUATE DEAN FOLLOWED BY THE NORMAL ACADEMIC PROCESSING

MEN SELECTED BY WESTINGHOUSE FOR ENGINEERING & DESIGN SCHOOLS HAD TO MEET ABOVE REQUIREMENTS BUT WERE WELL SELECTED AND NEARLY ALWAYS DID SO.

PROGRAM FOR SELECTED STUDENTS AND M.S. CURRICULA

O	1. ENGINEERING AND DESIGN SCHOOLS 9 MONTHS	15 CREDITS
X	2. MATHMATICS	4 CREDITS
X	3. CONVENTIONAL ENGINEERING COURSES	5 CREDITS
X	4. ONE DAY, WRITTEN COMPREHENSIVE EXAM	0 CREDITS
X O	5. RESEARCH AND THESIS	6 CREDITS
	TOTAL	30 CREDITS

O LECTURERS FROM INDUSTRY
X UNIVERSITY FACULTY

Summary

Throughout these honors programs, there has persisted a continuing desire to develop the natural ingenuity latent in the student's mind. This calls for more than increased analytical skill; it calls for the development of creative ability in engineering.

Throughout these developments, the University has recognized a responsibility to serve the professional needs of the Pittsburgh area. It has not allowed convention to retard development. Neither industry nor college has desired to compromise intellectual nor meaningful academic standards as they see them.

The students in these programs have

Table IV. The Design School Curricula in 1957

ADVANCED CALCULUS: 6 SEMESTER HOURS

A FAIRLY NORMAL COVERAGE WITH SOME EMPHASIS ON APPLICATIONS.
TEXT MATERIAL: QUADLING; HILDEBRAND; WIDDER

TRANSIENTS IN LINEAR SYSTEMS:
3 SEMESTER HOURS

USES LAPLACE TRANSFORM APPROACH
TEXT MATERIAL: GARDNER AND BARNES

LINEAR CONTROL SYSTEMS- I.
3 SEMESTER HOURS

PREVIOUS COURSE IS THE PREREQUISITE.
TEXT MATERIALS: CHESTNUT AND MAYER

MECHANICS OF MATERIALS:
3 SEMESTER HOURS

LECTURE NOTES BY INSTRUCTOR ON:
SOLIDS AND CRYSTALS
CRYSTAL STRUCTURE
THERMAL PROPERTIES
MAGNETIC PROPERTIES
ELECTRIC PROPERTIES

Table V. Graduate Evening Program Available to Honors Men along with All Other E.E. Graduate Students (Pittsburgh Area Only, 1955 through late 1957)

TOTAL NUMBER OF THREE HOUR GRADUATE COURSES SCHEDULED IN EVENING ONLY OVER PERIOD OF 2½ YEARS=42

PROPOSED TOTAL COURSE CANCELLATIONS FOR LACK OF REGISTRATION IN 2½ YEARS=9
(AVERAGE ENROLLMENTS EXCEED 12 PER CLASS)

MAJOR AREAS COVERED
1. ROTATING MACHINERY
2. CIRCUIT INTERRUPTION
3. POWER SYSTEMS
4. CONTROL THEORY
5. COMPUTING MACHINE THEORY
6. CIRCUIT THEORY
7. GENERAL ELECTRONICS

Table VI. The Way in Which the Original Westinghouse Atomic Power Fellowship Program Seems To Be Working Out

CALENDAR YEAR	TIME FOR STUDY	STUDIES AND	SEMESTER HOURS
1ST	FULL	DESIGN SCHOOL	12
		REACTOR SCHOOL	2 — 14
	PART	ON CAMPUS COURSES	12
		COMPREHENSIVE EXAM	0
		THESIS	6
		CREDITS FOR MS(IN EE)	30
		TOTAL CREDITS THIS POINT	44
2ND	PART	ON CAMPUS COURSES	15
		ORAL PRELIM.	0
3RD	FULL	TWO LANGUAGES	0
		QUALIFYING EXAM	0
		ON CAMPUS COURSES	13
		RESEARCH	8
4TH	PART	FURTHER WORK AND WRITING THESIS AT COMPANY	10
		EXAM & DEGEE	
		TOTAL GRADUATE CREDITS	90

(a) THE GENERAL PROGRAM

COURSE TITLE	SEMESTER HOURS
THEORY OF ELASTICITY	3
* DYNAMICS AND CONTROL OF REACTOR PLANTS	4
REACTOR THEORY	3
MASS AND HEAT TRANSFER	4
#(CHANGING TO 3) TOTAL SEMESTER HOURS	14

(b) DETAILS OF REACTOR SCHOOL MENTIONED IN GENERAL PROGRAM ABOVE

Table VII. Selection of Honors Men Relative to Others

GRADUATE RECORD EXAMINATIONS & OTHER TESTS FOR ENGINEERING AND SCIENTIFIC GRADUATES

TESTS FROM GRADUATE RECORD EXAMINATION	PERCENTILE ABOVE MEAN ROUGHLY 3000 INDIVIDUALS 1950-1956	ABOUT 50 HONORS MEN FOR YEAR 1957
ADVANCED ENGINEERING	+4	+34
SPATIAL VISUALIZATION	+25	
QUANTITATIVE	+24	+26
TOTAL VERBAL	+1	+11
GENERAL ABILITY	+2	+7

OTHER TESTS GIVEN HONORS MEN
(a) STRONG: INTEREST TEST.
(technical, administrative, communicative, arts, etc.)
(b) OTIS: IQ TEST.

Table VIII. Some Possible Programs

COURSE CLASSIFICATION	DEPARTMENT	COURSE DESCRIPTION AND CREDIT HOURS		TOTAL CREDITS	
COMMON COURSES	MATH E.E.	ADVANCED CALCULUS 3-6 TRANS. IN LINEAR SYST. 3-6 TOTAL HOURS 6-6		6-9	
REPRESENTATIVE EE OPTION WITH THESIS (30 CREDITS)	E.E.	A CONTROL SEQUENCE	AN INSTRUMENTATION SEQUENCE		UNDER STUDY
		LINEAR & NON-LINEAR CONTROL 6	ELECTRONICS 6 MAGNETIC AMPL. 3-0		
		REACTOR CONTROL 3	MEAS. & THEORY		
		ANALOG COMP. 3-0	OF ERRORS 3		
		SEMI-CONDUCTOR 3	SEMI-CONDUCTOR 3		
		SEMI-CONDUCTOR CIRCUITRY 3	SEMI-CONDUCTOR CIRCUITRY 3		
		COURSE HOURS 15-15	COURSE HOURS 15-15	15-15	
		THESIS 6	THESIS 6	6	
		TOTAL FOR M S WITH THESIS		30	
A POSSIBLE EE-NUCLEAR OPTION WITHOUT THESIS (36 CREDITS) -UNDER STUDY	MATH & EE E.E. CHE. ENG. M.E. PHYS.	CARRIED OVER FROM ABOVE: COMMON COURSES CONTROL, INSTRUMENTATION OR OTHER EE SEQUENCE TOTAL CARRIED OVER		6-9 12-9 18	18
		ADDITIONAL COURSES: INTRO. TO NUCLEAR ENGG. THERMO HEAT TRANSFER FLUID DYNAMICS PHYSICS TOTAL ADDITIONAL HRS. TOTAL HOURS		6 3 3 3 18	18 36
FURTHER WORK	E.E.	SUBSEQUENTLY 6 HOURS RESEARCH REQUIRED AS INITIAL PART OF Ph.D WORK			

Table IX. Trends in Honors Programs in Electrical Engineering over Past 45 Years

STUDIES \ YEARS	SEMESTER-CREDIT HOURS 1927	1927-1940	1940-1952	1952-1955	1955-1957	1957 —	UNDER STUDY
ENGINEERING SCHOOL	0	3	3-0	0	0	0	
DESIGN SCHOOL	0	12	12	12	12	15	
MATHEMATICS (REQ.)	—	4	6	6	6	6	
OTHER ENGR. COURSES	—	5	3-6	6	6	3	15
WRITTEN COMPREHENSIVE (ONE DAY)	—	YES	YES	YES	YES	YES	YES
THESIS	—	6	6	6	6	6	0
SEMESTER HOURS AND DEGREE	— —	30 MS	30 MS	30 MS	30 MS	30 MS	36 MS
REACTOR SCHOOL	—	—	—	—	14	14	—
RESEARCH AND REPORT	—	—	—	—	—	—	6
ORAL PRELIM.	—	—	—	—	YES	YES	
OTHER COURSES	—	—	—	—	28	28	30
LANGUAGES	—	—	—	—	TWO	TWO	
QUALIF. EXAM WRITTEN 3-4 DAYS)	—	—	—	—	YES	YES	
THESIS	—	—	—	—	18	18	
SEMESTER HOURS AND DEGREE	—	—	—	—	90 Ph.D.	90 Ph.D.	

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been well selected, and their professional records after graduation are uniformly good to excellent. How much of this is caused by selection and how much of it is training will never be known.

A new operating principle seems to be arising which is that of interleaving industrial people and full-time teaching staff. The one spends most of his time on industrial research and development and teaches part time; the other reverses this process.

Table IX shows something of the trend over a period of 45 years from the old company schools set up by the great inventor and designer, B. G. Lamme, to the new and very flexible present-day fellowship programs. The old schools served a company's needs; the new may serve the needs of many industries.

Subject matter has changed but purpose has remained unchanged. Now, as 45 years ago, the purpose is to develop men who can design, discover, invent, organize; in short, to develop men who can think on their own.

Off-Campus Program in Engineering Inaugurated

An off-campus program in engineering leading to a master of science degree has been inaugurated in the Santa Clara–San Mateo area this Fall by the Graduate Division and the department of engineering of the University of California (UC) in cooperation with University Extension.

The first course, "Engineering Analysis" is being given in Sunnyvale, Calif. Other off-campus courses scheduled for the future are "Introduction to Solid-State Physics," "Applied Electromagnetic Theory," and "Advanced Engineering Dynamics."

Students who enroll in the program must meet the regular admission requirements of the UC Graduate Division and the department of engineering and must register as regular graduate students.

The off-campus portion of the program, comprising four courses and 12 units of credit, will prepare the student for a master's degree in either electrical engineering or mechanics. The on-campus part of the program, consisting of four more courses and 12 more units of credit, normally can be completed in one semester of residence at Berkeley.

Evening classes for graduates are being offered in the Peninsula area in order to accommodate full-time employed students there, according to C. T. Singleton, head of UC Engineering and Sciences Extension which office administers the program.

"During the past year and a half, the University has offered off-campus graduate programs in engineering science, physics, and mathematics in Livermore," Mr. Singleton said. "The engineering science program inaugurated in Sunnyvale is another effort of the University to extend its resources whenever possible and to meet particular community needs. By locating the new program in Sunnyvale, it is hoped that the engineering graduate requirements of the Santa Clara–San Mateo industrial community can be served adequately."

Further information about the program may be obtained from the Engineering Graduate Office, Room 312, Engineering Building, University of California, Berkeley 4, Calif.

Instrumentation Conference at Louisiana Polytechnic Institute

The School of Engineering, Louisiana Polytechnic Institute, Ruston, La., announces the 7th Annual Instrumentation Conference to be held on the campus, November 6-7, 1958.

An interesting program is being arranged which includes the following papers to be presented at the technical sessions: "Fundamentals of Instrumentation and Controls," by Dr. Virgil Orr, head, department of engineering research, Louisiana Polytechnic Institute; "Instrumentation for Continuous Digesters," by R. F. Barber, The Foxboro Company, Foxboro, Mass.; "Automatic Control and Instrumentation of a High Pressure, High Temperature Steam Generating Unit," by Harold McMichael, Leeds & Northrup, Houston, Tex.; "Design and Application of Orifice Fittings and Meter Tubes," by Ralph Clemons, Daniel Orifice Fitting Company, Houston, Tex.

Exhibits of new equipment in instrumentation and process control will be displayed by representatives of the leading manufacturers of such equipment.

Recent Engineering Faculty Appointments

The University of Michigan, Ann Arbor. Three appointments in the College of Engineering have been announced. R. A. Dodge has been reappointed chairman of the department of engineering mechanics. E. L. Eriksen, professor emeritus of engineering mechanics, has been reappointed as a lecturer in industrial engineering and consultant in the educational field for Japanese participants in the ICA co-operative program with Waseda University. W. M. Brown has been appointed assistant professor of electrical engineering. Dr. Brown was formerly a member of the technical staff, Institute for Defense Analysis, Washington, D. C., as well as associate professor and lecturer at George Washington University.

Northwestern University Technological Institute, Evanston, Ill. R. R. Jenness has been promoted to professor of electrical engineering, and C. W. McMullen has been named associate professor of electrical engineering. Both men have been active in the National Electronics Conference: Prof. Jenness was president in 1955-56 and Prof. McMullen is currently serving as treasurer of the organization.

University of Wisconsin, Madison. Prof. A. T. Lenz has been chosen chairman of the civil engineering department. Beginning his career on the University of Wisconsin staff in 1929, Prof. Lenz has done considerable research in the hydraulics and sanitary engineering laboratory in dam construction and hydrology, and water resources investigations. Dr. M. W. Carbon, thermodynamics expert who had been working on development of the ICBM nose cone for the United States guided missile program, has been appointed to direct the University of Wisconsin's expanding Nuclear Engineering Program.

Ohio State University, Columbus. H. A. Bolz has been named dean of the College of Engineering. Associate dean of the College since joining the Ohio State staff in 1954, Dean Bolz had been serving as acting dean since March 1958. Dean Bolz was also given the title of director of the Engineering Experiment Station and retains a full professorship in the department of mechanical engineering.

New York University. Prof N. N. Barish, of the industrial and management engineering department at New York University's College of Engineering, has been named associate dean of the College.

Refresher Institutes at UW Extension Division

The University of Wisconsin (UW) Extension Division has announced a series of refresher institutes designed to help Wisconsin engineers prepare for registration examinations conducted by the State Board of Engineers.

The institutes are designed to help engineers gain professional status and have been endorsed by the Wisconsin Society of Professional Engineers as part of its "pet drive" to obtain 100% registration in the State. State law requires engineers to pass the registration examinations before they practice independently.

C. F. Hure of the UW Extension Division's Engineering Institutes said there are 4,808 registered professional engineers in Wisconsin, along with an estimated 5,000 college engineering graduates who have not completed state requirements. He said each engineer must pass the basic examination plus one in his specialty to qualify for registration.

The basic engineering institute was held on the university campus October 16-17. Other scheduled refresher programs include civil engineering, November 20-21; chemical, mining, and metallurgical engineering, January 29-30; mechanical engineering, February 26-27; and electrical engineering, April 23-24.

Among lecturers at the institutes will be State Chief Engineer R. D. Culbertson; W. A. Piper, secretary of the Wisconsin Registration Board of Architects and Professional Engineers; and Dean K. F. Wendt of the UW College of Engineering. Other faculty members will represent the

various University engineering departments.

Clifford Nelson, Black River Falls, president of the Wisconsin Society of Professional Engineers, said every engineer in the state should prepare for and pass the state examinations to remove "an important gap in their professional stature."

He said that registration of engineers is required by the state in order to protect the public. The examinations are designed to stop the practice of engineering by nonengineers and to oust from the profession those who are incompetent.

Voice of Democracy Winner Is To Receive $1,500 Scholarship

A $1,500 college scholarship will be awarded to the high school student who wins the 1958-59 Voice of Democracy scriptwriting contest, the National Association of Broadcasters (NAB) and Electronic Industries Association (EIA), sponsors of the contest, have announced.

The top winner may use the scholarship at any college he or she chooses. This scholarship is administered by the National Association of Secondary-School Principals, a department of the National Education Association.

Each of the four semifinalists will receive a gold recording of his or her winning entry. In addition, the University of Missouri School of Journalism will present $500 scholarships to each semifinalist as part of the school's 50th Anniversary celebration.

The top national winner will be chosen from among these four semifinalists and will receive the $1,500 scholarship in addition to a $500 scholarship.

Officials of the Missouri School of Journalism said one of the objectives of the 50th Anniversary observance is to help foster in the youth of the United States greater interest in public communications. The school is offering scholarships to semifinalists in recognition of the competition's success in stimulating this interest among hundreds of thousands of young people.

Alumni of the School of Journalism will participate in efforts to bring the contest to the attention of high school students and their parents.

The four semifinalists will be chosen from among the winners in each of the 49 states and the District of Columbia.

The contest is being co-sponsored on the state level by state broadcasters associations.

Each state winner will be brought to Washington, with all expenses paid by EIA and NAB, for the national award ceremonies in February 1959, and for a 4-day tour of the nation's capital.

This is the 12th consecutive year that the contest has been held. It is open to all 10th, 11th, and 12th grade students in all public, private, and parochial schools throughout the 49 states and the District of Columbia. Some 28,000 secondary schools already have received contest announcements and invitations to participate.

Each contestant writes a three- to five-minute broadcast script on the theme, "I Speak for Democracy," and then delivers the script orally in competition with other contestants in his or her school. Scripts are judged on the basis of content, delivery and originality. The winner in each school competes in a community- or county-wide contest. The community or county winner's script is tape-recorded, and the state and national winners are selected on the basis of these tape-recordings.

Contests will be held in the schools during the Fall.

The National Association of Secondary-School Principals has placed the contest on its Approved List of National Contests and Activities for 1958-59. The contest also is endorsed by the U. S. Office of Education.

Broadcasters associations from the following states already are participating in the contest: Alabama, Arizona, Colorado, Connecticut, Florida, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland–D.C., Massachusetts, Missouri, Nebraska, New Mexico, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Utah, Vermont, Virginia, Washington, West Virginia, Wisconsin, and Wyoming.

Catholic University Appoints Research Co-ordinator

A special office to expand and co-ordinate university research activities has been established at The Catholic University of America (CU), Washington, D.C., according to an announcement made by the rector, Rt. Rev. Msgr. W. J. McDonald.

At the same time, Msgr. McDonald announced the appointment of F. G. deBettencourt, aeronautical engineer and 1948 CU graduate, as first co-ordinator of research.

The newly created office will centralize administrative aspects of the University's growing number of basic and applied research contracts, obtain sponsorship for new or continuing research, and develop a full level of research activity compatible with the needs and enlarging capability of the University.

During the past year, CU has redoubled its efforts to provide facilities for an increase in the amount and quality of basic research in its graduate courses. The beginning of the academic year 1958-59 saw the institution of courses in nuclear energy technology, use of the atomic reactor presented to the University by the Atomic Energy Commission, and the opening of the recently constructed Keane Physics Research Center. In February, 1958, at the dedication of the center, Dr. J. R. Killian, Jr., President Eisenhower's special assistant for science and technology, lauded the pioneering research work done by CU scientists, especially in X-ray and aeronautical engineering.

Mr. deBettencourt, a native Washingtonian, came to his position as co-ordinator of research from the Aircraft Industries Association of America, Inc., where he had been a member of the technical staff of the Washington office of this aeronautical trade association. He was also national secretary of the Engineering Contract Requirements Committee and the National Aircraft Standards Committee.

He has served in technical, sales, and administrative positions with various aircraft companies.

A bomber pilot in Europe during World War II, Mr. deBettencourt returned to active duty with the Air Force during the Korean conflict as research and development officer in aerodynamics at the Dayton, Ohio, Wright Air Development Center of the Air Research and Development Command.

Short Course for Engineers and Managers Set

An intensified 10-day short course for engineers and managers will be held January 26-February 5, 1959, on the Los Angeles Campus of the University of California.

The Engineering and Management Course is designed to assist in the continuing development of engineering and management personnel by increasing their present effectiveness and by preparing them for the higher responsibilities. All levels of engineering and management personnel will be able to select a program from the wide selection of subjects offered, suited to their individual needs.

There are no formal educational requirements. The course fee is $400 which includes tuition, books, required materials, 10 luncheons, and 1 dinner. Living accommodations are available within a reasonable distance of the campus.

Further information may be obtained by writing to: Engineering and Management Course, Room 3104 Engineering Building, University of California, Los Angeles 24, Calif.

New Teaching Method for Civil Engineering Effective

Use of project-type instruction—similar to the case study method in legal training—initiated last year in civil engineering courses at The Cooper Union for the Advancement of Science and Art, New York, N. Y., proved so successful that it was planned to expand it in September.

This innovation in engineering education was described by Dr. C. F. Peck, Jr., head of the civil engineering department, in his annual report. The Cooper Union

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engineering and art schools are tuition-free and their students are selected through rigorous examinations.

In the project-type instruction reported by Dr. Peck, sophomore students under guidance of Dr. F. A. Wallace, professor of civil engineering, were introduced to civil engineering by working out in detail certain specific problems.

In one problem, they were assigned the design of a highway overpass. Not only did students study the problem of supporting the structure and designing it, but also the social implication of such a structure in the community.

Moreover, students were required to provide justification for the cost of the underpass in terms of the time element and human life saved by the elimination of a grade crossing. They also had to consider the economic gains and losses to local business which might result from the rerouting of traffic.

Another typical problem was taken from the hydraulics field. Students were assigned the design of a box culvert to carry the run-off from a specified area under a highway.

For this problem, a small valley in nearby northern New Jersey was selected so that students, on their own time, could go out and study the existing culvert, which presumably was designed to carry the run-off. At the same time they were able to see the ground as shown by the topographic maps given them.

The development of project-type instruction was also integrated with field work at Cooper Union's Green Engineering Camp, a 1,000-acre tract in the Ramapo Mountains in northern New Jersey, Dr. Peck reported. Third-year students, during the Spring term course on structures, designed a wooden truss bridge to cross the Ringwood River which flows through the Camp.

Junior students, with the aid of sophomores, fabricated and erected this bridge during the engineering school session. They did all the precise surveying required to locate the foundation and planned all fabrication and erection on the basis of its being a major river crossing.

"This experiment in education by doing was highly successful," Dr. Peck reported, adding that other projects at the Camp will be worked into the program in the future. The sheer pleasure that students got out of actually designing and building a permanent structure left them with increased desire for learning and doing engineering work. Perhaps most important was that students have a better feeling for the man who has to build something from their drawings.

As an indication of the high scholarship standards at Cooper Union, the report indicated that 13 of 15 day-school 1958 graduates and 3 of the night-school graduates, are planning to go on to graduate school.

New President of Eta Kappa Nu Announced

Larry Dwon (M '43), of Glen Rock, N. J., manager of engineering manpower for the American Electric Power Service Corporation, New York, N. Y., has been elected national president and board chairman of Eta Kappa Nu Association.

Eta Kappa Nu is an electrical engineering honor society with more than 28,000 members in American universities and industry. It has 66 student chapters in nationally accredited colleges and universities and 12 alumni chapters, with its members selected for demonstrated leadership, scholastic attainment, and extra-curricular activities.

Also elected to national office were: Dr. J. G. Tarboux, professor of electrical engineering at the University of Michigan, vice-president and board vice chairman; Prof. P. K. Hudson, department of electrical engineering, University of Illinois, executive secretary and director; and the following directors for 2-year terms: J. H. Craig, Short Hills, N. J., Bell Telephone Laboratories—Eastern Region; Prof. J. D. Tillman, associate professor of electrical engineering, University of Tennessee—Central Region; and Dr. G. T. Harness, associate dean of the School of Engineering, University of Southern California—Western Region.

Mr. Dwon is a 1935 electrical engineering graduate of Cornell University and received his masters degree in business administration from New York University. He has taught electrical engineering in the evening schools of Pratt Institute of Technology and the Polytechnic Institute of Brooklyn. He is the author of several technical papers and articles and is a member of the American Society for Engineering Education.

Air Force Contract Awarded to Case Institute

A $51,257 unclassified U.S. Air Force research contract has been awarded Case Institute of Technology by the Air Force Cambridge Research Center at Bedford, Mass., school officials have announced.

Granted to three members of Case's electrical engineering department faculty, the contract calls for a study of "Control of Aperture Fields."

Named as directors of the research program under the contract are Dr. Robert Collin, Dr. Beaumont Davison, and Dr. Robert Plonsey, all assistant professors in the electrical engineering department. Actual work began June 1, and the contract will run through May 1959 at which time it may be renewed.

A major portion of research carried on at Case is financed by Government agencies. In 1956-57, according to a 10-year report by Case President T. K. Glennan, the U.S. Government spent a total of $1.039 millions for research at Case.

Coupled with $417,000 in additional research dollars from private industry, Case's total research picture in 1956-57 amounted to $1.652 million. This marks a more than 300% increase in research activity since President Glennan arrived as the school's fourth president in 1947.

The stature of institutions such as Case is measured by the school's reputation in research and graduate work. School officials have announced a program of expanded activity in research and graduate education, necessary in order to continue to attract the best quality of undergraduates and faculty.

EMC–SMC Forecast of Engineering Graduates

Following, by curricula, is the forecast of engineering graduates for 1959 made by the Engineering Manpower Commission (EMC) of Engineers Joint Council and the Scientific Manpower Commission (SMC). Mortality rates have been changing—for the worst—in recent years so the development of these figures is not as simple a statistical exercise as some may imagine. 1957 and 1958 figures are presented also to provide some idea of the trends.

Engineering Bachelor Graduates

From Colleges With ECPD Accredited Curricula	(1956-57) 1957 Actual	(1957-58) 1958 Estimated	(1958-59) 1959 Projected
Aeronautical	984	1150	1300
Chemical	2712	3000	3100
Civil	4275	4900	5300
Electrical	7510	8500	9500
General	624	675	750
Industrial	1595	1800	1900
Mechanical	6952	7900	8700
Metallurgical	572	650	75
Mining	481	525	600
Petroleum	644	750	800
All others	1399	1650	2300
Total	27748	31500	35000
From other Colleges	3463	3500	4000
Grand Total	31211	35000	39000

INSTITUTE ACTIVITIES

Sacramento Section Acts as Host to the 1958 Pacific General Meeting

THE AIEE Pacific General Meeting was held in Sacramento, Calif., August 19-22, 1958, with headquarters in the Hotel Senator. The program, administered by the Sacramento Section, comprised a full schedule of events consisting of a general session, 15 technical sessions, social features, inspection trips, student activities, and a golf tournament. In addition, several important committee meetings were held as well as an all-day meeting of the Board of Directors on August 21. The total attendance at the meeting was 611 members and guests.

General Session

The meeting was opened by C. R. Day, general chairman, who extended a cordial welcome and introduced the officers present, including Past-President and Honorary Member R. W. Sorensen, who is the father of Mrs. F. J. Groat, chairman of the Ladies' Program Committee.

75th Anniversary Celebration

An address by President L. F. Hickernell laid the plans for the celebration of the 75th Anniversary of the Institute in which history will be used as a springboard to the future exemplified by the slogan adopted, "75 Years—A Prologue to the Future." The early history leading up to the founding of the Institute in 1884 was traced by President Hickernell, who then described the expansion of the organization including plans for its future. The complete address appears in *Electrical Engineering*, October 1958, pp. 889-91.

Power in the California Water Plan

An address by H. O. Banks, director of water resources, explained the California water plan and stressed the economics of the pumping requirements in relation to changing costs in steam electric, hydroelectric, and nuclear energy. Approximately ⅔ of California's water resources originate north of Sacramento whereas 70% or more of the estimated future water demand will come from the south of this city. The speaker explained that the California water plan represents nine years of engineering studies and expenditure of nearly $10 million. The result is a master plan with which all future water developments should conform. The plan was developed in three phases: first, a thorough inventory of all the state's water resources; second, a thorough inventory of all present and future water requirements; and third, a basic engineering framework to show that with co-ordinated effort, the problem of controlling, protecting, serving, and redistributing the state's water resources can be solved in order to fulfill total future requirements. The possibility of saline water conversion was also taken into consideration but the speaker did not believe that the practical application of sea water conversion on a large scale at competitive costs would enter the picture for at least 20 years or more.

Future Thermal Electric Power Plants on the PG&E System

An address by C. C. Whelchel, chief mechanical engineer of the Pacific Gas and Electric Company (PG&E), reviewed the system load growth of that company with its changing electric power supply and fuel requirements along with the roles that hydroelectric plants, conventional steam plants, and nuclear fission plants will play in the generation of power in the most economical manner. Using slides for illustration, the speaker explained design features of conventional steam power plants including new units, No. 5 and No. 6, at Pittsburg, Calif., which raised the total generating capacity to 1.25 million kw, making that plant the largest in the West. Nuclear activities also were discussed including experience at the GE Vallecitos plant and plans for the Humboldt Bay Unit No. 3, as well as a comparison of conventional and nuclear power costs.

Vice-President O. A. Gustafson introduced President Hickernell, and F. J. Groat, vice-chairman of the General Committee, introduced the speakers.

The chairman of the Finance Committee for the meeting, P. E. Shaad, was presented with a Fellow diploma by President Hickernell.

The chairman of the Sacramento Section, R. N. Keen, explained that the Section was only 9 years old and at present included about 175 members. C. R. Day was the first Section chairman. Tribute was paid to the active Women's Auxiliary of the Section.

Student Activities

The Student Branch Counselors of Districts No. 8 and No. 9 held a business meeting on Wednesday. President Hickernell addressed the meeting outlining the growth in the Student Branches and offering valuable suggestions gained from long practical experience which would aid the officers, counselors, and Branch chairmen in the conduct of meetings. Full text of the address appears in this issue of *Electrical Engineering*, pp. 1034-35.

An interesting talk was given at the Student Luncheon meeting by Dr. W. K. Woods, assistant manager of the Vallecitos Nuclear Plant. The speaker briefly outlined the history, opportunities, and challenges that exist in nuclear energy work. Among the facts he mentioned was that in 1933, the neutron was first isolated and identified bringing the system in order for the first time in the periodic table. He also pointed out that energy released from fission is 100-million times that released by chemical reaction. He said that uranium is the key material in the nuclear field and that large quantities of power, 10% of all the power in the United States, is used to separate U-235 from U-238. Many challenges are offered through the production of the new materials wtih new physical

AIEE PRESIDENT L. F. Hickernell *(left)* presents a Fellow diploma to P. E. Shaad, 1956-57 chairman of the Sacramento Section, during the Pacific General Meeting of the Institute in Sacramento, Calif., August 19-22, 1958.

AT THE SPEAKERS' TABLE during the luncheon for Students and Branch Counselors held during the AIEE Pacific General Meeting were: *(left to right)* G. N. Kapendritis, J. L. Knickerbocker, Dr. W. R. Woods, R. W. Armstrong, and W. R. Parish.

properties in the field of isotopes, radiation, biology, and medicine. The speaker concluded by quoting a remark by Dr. Bennett to the effect that if Watt's steam engine created an industrial revolution, what may we expect of nuclear power?

Dr. Pickering Addresses Luncheon

Before a large gathering of members and guests at the luncheon held on August 21, Dr. W. H. Pickering, director of the Jet Propulsion Laboratory, California Institute of Technology, spoke on the subject, "An Electrical Engineer Looks at the Space Age." In introducing the subject, the speaker pointed out that it was nine months since the Soviets launched the first Sputnik and that we were entering a new space era. All that had been done so far was to put a vehicle with a few instruments in orbit which is a long way from science-fiction aspects. He stated that since the nearest star was of the order of four light years away, flight time, at speeds of five miles per second, would require 150 years; hence, it would be necessary to have much faster vehicles. He said that 13 pieces of hardware had been floated around in the past seven to nine months with the result that measurements had been made of meteorites and temperatures. The Soviets have made similar measurements with the addition of the biological experiment using a dog. Much of their quantitative data, which takes considerable time to process, has not been seen.

In regard to a rocket flight to the moon at a speed of seven miles per second, the speaker stated that there was a considerable extra guidance problem created by the movement of the moon. Because of the dog experiments, he thought that perhaps the Soviets were more interested in putting a man up in space. We should realize that we are behind the Soviet Union which undoubtedly will be able to show other achievements in the coming years.

Dr. Pickering urged a more logical approach to the problem. For the moment, he did not see that the Space Age would have the same impact as nuclear energy on civilization and that it would be a long time before there would be a commercial impact resulting from space vehicles. Speaking about the electrical engineering aspect, he said that electrical engineers would be needed for the synthesis of fuels. Space vehicles must have power during the voyage and guidance introduces a severe problem as compared with communication, particularly when it is considered that the flight to Mars might involve travel of 50-million to 100-million miles. Also to be considered is the question of propulsion and the type of fuels that would be used. Tremendous speeds might be attained with small accelerators but miniaturization is essential to keep down weight. In conclusion, Dr. Pickering recommended a study of the problem of the conquest of space to the entire audience.

The speaker was introduced by Past-President R. W. Sorensen. Vice-Chairman of the meeting, F. J. Groat, introduced the officers and guests at the head table including J. M. Landis, president of the American Society of Mechanical Engineers (ASME). Mr. Landis commented that he had spent considerable time in the local Sections trying to sell the AIEE functional plan of organization. He also drew attention to the fact that PG&E had donated the original Folsom Hydroelectric Plant to the State Parks Commission as an historical monument which would be commemorated on the following day, August 22.

Technical Sessions

In 15 technical sessions held during the 4-day meeting, 62 papers were presented. In the power field, sessions dealt with relays and rotating machinery, power generation, insulated conductors, substations, and transmission and distribution. In addition, there was a session on nucleonic and radiation instrumentation embracing papers which dealt with the sodium reactor, instrumentation for a boiling water reactor, control requirements for nuclear power plants, and data handling systems. In the session on relays and rotating machinery, considerable interest was manifested in a paper on "A New Brushless Alternator with Electromagnetic Excitation." These alternators in capacities from 1 to 5 kva can be designed within a space of 7 by 7 by 7 inches, weigh less than 32 pounds and operate at 20,000 cycles. They have low inertia and the bearing loads are a minimum during violent maneuvers a fact which is very important in space flight. The session on power generation dealt mainly with hydroelectric developments such as performance of generator thrust bearings, reversible pumped-storage units, the impact of atomic energy on water resources development in California, and motor-driven vs shaft-driven exciter tests.

In the industrial field, two of the sessions treated 480-volt system design, the applications of air circuit breakers, the uses of aluminum wire and cable, and portable and emergency power supply. Other sessions on domestic and commercial applications, and space heating, had to do with special problems encountered within the area, solar heating, the heat pump, and gas vs oil for residential heating. Two of the other sessions were on the subject of feedback control systems.

Radio and wire communications were the subjects of two other sessions. These embraced papers which had to do with the 6,000-mc radio system for toll telephone service, expansion of the Pacific Coast microwave network, traffic light control, capacitance tuning, and atmospheric influences on 36-kilomegacycle propagation. The California–Hawaii transoceanic telephone cable was described, which, aside from the use of higher potentials, involves no changes from the Atlantic cable design. The repeaters can be repaired as explained by the author, J. W. Dunbar, American Telephone & Telegraph Co. Other papers described the newer types of carrier telephone systems.

A session on computing devices dealt with the problems of storage, mathematical methods for programming, and digital design problems. In the transmission and distribution session, a paper presented by Miss J. C. Siegel was on the subject of nodal representation of large complex-element networks including mutual reactances. Dr. W. A. Lewis, who presented two papers in the transmission and distribution session, raised the question of including impedance resulting from the ground resistance effect since this is always encountered in practice.

A session on management, research, and system engineering had to do with the economic selection of generating capacity additions as well as managing research laboratories.

Dedication of Original Folsom Plant as a Historic Landmark

On August 22, the original Folsom Hydroelectric Plant, donated by PG&E to the State of California to preserve its historical values, was dedicated by the unveiling of a plaque at the site. The plaque was placed by the California State Park Commission in co-operation with the Sacramento Section of the AIEE. This plant marked one of the earliest installations to generate hydroelectrically 3-phase alternating current to be delivered to the City of Sacramento at 11,000 volts over a transmission distance of 22 miles. The plant

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grades, qualifications, and fees may be obtained from Mr. N. S. Hibshman, Secretary, 33 West 39th Street, New York 18, N. Y.

went into operation in July 1895 and on September 9, 1895, the state capitol, decorated with electric lights from the energy supplied at Folsom, marked the occasion with a "great electric carnival." The plant was operated continuously until 1952, when the construction of the new dam forced it to shut down. Welcome and introduction of distinguished guests were made by P. E. Shaad; the presentation was made by L. H. Anderson, vice-president of PG&E; and the bronze plaque was accepted by the Honorable J. R. Knowland, chairman, California State Park Commission.

Inspection Trips

Besides the inspection trip to Folsom Dam and power house, trips were arranged to the Aerojet-General Corporation, McClellan Air Force Base, Elverta and Hedge Substations of the Sacramento Municipal Utility District, the United States Army Signal Depot, and the Procter & Gamble Plant.

Social Activities

An informal "get acquainted" gathering was held at the Hotel Senator on Monday evening. On Tuesday evening, a wine tasting festival was arranged where several hundred choice wines were available for sampling. On Wednesday night, a number of members and guests attended the stage production, "The Most Happy Fella." This was produced by the Lewis and Young Theatrical Company in a round circus tent. The luncheon addressed by Dr. Pickering was previously mentioned, and the climax to the entertainment program was a Hawaiian Luau held on Thursday evening. The Luau was served by "hula girls" and "beach boys" to the accompaniment of authentic Hawaiian music and entertainment followed by dancing.

Ladies Activities

In addition to the foregoing events, a special program for the ladies was arranged by the Ladies' Program Committee under the chairmanship of Mrs. F. J. Groat. A coffee hour was held at the hotel on Wednesday and Thursday mornings with opportunity to play cards or relax and chat with others. On Tuesday, a tour of the California Governor's Mansion was followed by an afternoon tea at the famous Crocker Art Gallery. Wednesday, a luncheon trip was taken to the fashionable Sacramento Inn, where a fascinating talk was given by Mrs. Joyce Peters, a lady engineer. The aims and objectives of the Sacramento AIEE Wives' Club were explained. On Thursday, the ladies took a trip to the Tide and Oxydol Plant of the Procter & Gamble Company, and on Friday morning, a brunch with swimming and bridge was arranged at the El Mirador Hotel.

PLAQUE COMMEMORATING the original Folsom Hydroelectric plant as a California historical landmark placed by the California State Park Commission in co-operation with the Sacramento Section of the AIEE. Shown around the plaque are: (*left to right*) L. O. Haupt, R. Hayden, W. L. Hill, and A. Neasham. The dedication ceremonies took place on August 22, during the 1958 AIEE Pacific General Meeting.

Golf Tournament

The golf tournament held on August 21 was played at the Haggin Oaks Golf Course. The first flight winner was Art Gingell, San Francisco, and Clint Pooley, Sacramento, was runner-up. The second flight winner was Jack Peterson, University of Santa Clara, and Merritt Pruitt, Sacramento, was runner-up. The third flight winner was Marlen Davis, Sacramento.

Committees

The officers and chairmen of the Pacific General Meeting Committee which made the arrangements were as follows: general, C. R. Day; finance, P. E. Shaad; hotel arrangements, E. P. Price; publicity, M. N. Davis; printing and tickets, A. O. Clark; inspection trips and transportation, L. O. Haupt, Jr.; entertainment, I. E. Ball; registration, E. C. Sparrow; sports and recreation, E. J. Keogh; students, R. W. Armstrong; ladies program, Mrs. F. J. Groat; and meetings, J. E. Chester.

AT THE GOVERNOR'S MANSION, a trip which was part of the Pacific General Meeting's Ladies' Program were: (*left to right*) Mrs. F. J. Groat, chairman of the Ladies' Program Committee; Mrs. G. J. Knight, wife of the Governor; and Mrs. R. N. Keen, wife of the chairman of the AIEE Sacramento Section.

Luigi Emanueli Named Honorary Member of the Institute

Luigi Emanueli

ONE OF THE HIGHEST HONORS of the AIEE, that of Honorary Membership in the Institute, has been conferred upon Luigi Emanueli (M '28, F '36, Member for Life), general manager of Pirelli Società per Azioni, Milan, Italy, ". . . as one who has rendered acknowledged eminent service to electrical engineering."

The presentation to Mr. Emanueli was made during October at the Castello degli Arcimboldi by Dr. Alberto Pirelli, who represented the President of AIEE. Instrumental in arrangements for the ceremony was Prof. Barbagelata, general secretary of the Associazione Elettrotecnica Italiana (AEI).

Mr. Emanueli is the 45th person to be chosen for Honorary Membership in the AIEE. Living members so honored include: Vannevar Bush, James F. Fairman, Herbert Hoover, Andrew George Latta McNaughton, Donald A. Quarles, Motoji Shibuzawa, and Royal Wasson Sorensen.

Mr. Emanueli obtained his degree in industrial electrotechnical engineering at the Milan Polytechnic in 1906, and entered the Pirelli Company on August 1, 1907.

His father, Leopoldo Emanueli, also an engineer of repute, was one of the first collaborators of the founder of the Pirelli Company, Gian Battista Pirelli, and specialized in the field of mechanics. He created some of the first machines for the manufacture of cables, especially for those insulated with impregnated paper, and developed original taping machines, some of which are still in operation.

On entering the Pirelli Company, Luigi Emanueli was at once attracted to original studies and research in the field of electrotechnics, and was among the first to realize the importance of the phenomena of dielectric losses at a-c. He did, in fact, read a paper on this subject entitled "Experimental Research on Dielectric Losses," at the AEI on December 11, 1908.

At that time, he commenced, for the first time in the cable industry, to measure the dielectric losses in cables with methods and apparatus (measuring bridges) of his own design, which still bear his name. These studies led him in 1911 to the very important discovery that the dielectric losses increase with the voltage due to gaseous occlusions in the dielectric (known as the ionization factor). This knowledge, which Mr. Emanueli applied for some time only for his own studies, brought him finally to the invention of the oil-filled cable for extrahigh voltages.

His studies also covered the characteristics of insulating materials, particularly paper and impregnating compounds, and he was the first to investigate the process of the impregnation of paper insulated cables with scientific methods. In 1911, after having completed his theoretical and experimental studies, he emphasized the immense importance of the viscosity of the compound and of the porosity of the insulating paper on the process of impregnation. For this purpose, he elaborated porosimeters and viscosimeters of his own design, which are now universally associated with his name.

In 1919, he made the fundamental discovery of the correlation between the porosity of the insulating paper and the dielectric strength of the paper after impregnation.

In 1918, he designed and supervised the manufacture of the first length of oil-filled cable, now internationally known as the "Emanueli cable." The results obtained in laboratory tests on this first length were entirely unexpected and truly remarkable, the transformer used for the test being quite inadequate to cause breakdown of the cable.

In 1920, Messrs. I.L.V.A., of Piombino, placed an order with Pirelli for 4 km (kilometers) of 80,000-volt cable (1 by 100 MCM). It was decided to offer an oil-filled cable, which was manufactured the same year with excellent results. Unfortunately, this cable was never laid because the customer no longer needed the line. The reels of cable were therefore stored in the factory for about 4 years, but during that time research and tests on this type of cable continued until the conviction grew that the cable which had been made for a working tension of 80 kv could very well carry 132 kv.

In agreement with Società Interregionale Cisalpina, a length of 1,000 feet of this cable was therefore installed at Brugherio, near Milan, in 1924 in connection with a 132-kv line belonging to the company. This experimental line operated from 1924 to 1928 without the slightest trouble being experienced in service.

As a result of this demonstration, in 1926 the Consolidated Edison Company of New York and the Commonwealth Edison Company of Chicago placed an order for two 132-kv oil-filled cable lines, respectively of 18 and 9 km, capable of carrying 100,000 kva. As is known, a part of these cables were manufactured in Italy by Pirelli, and a part in the United States by the General Electric Company, under the supervision of Pirelli engineers, and they were put in service on June 2, 1927, in Chicago and on August 9, 1927, in New York. The results have been entirely satisfactory, and these lines constitute the first realization in the world of a cable operating at a voltage higher than 60 kv, and the first oil-filled cable installed for industrial service.

In Italy the first oil-filled cable was laid in 1928 with a 132-kv line, and in the same year 66-kv and 100-kv cables were installed respectively in England and Germany.

The year 1924 saw another milestone in the history of very high voltage cables. At the World Power Conference held in London that year Mr. Emanueli read a paper demonstrating that it would not be possible to use cables for extrahigh voltages

Conference Papers Open for Discussion

Conference papers listed below have been accepted for AIEE *Transactions* and are now open for written discussion until November 26. Duplicate double-spaced typewritten copies of each discussion should be sent to E. C. Day, Assistant Secretary for Technical Papers, American Institute of Electrical Engineers, 33 West 39th St., New York 18, N. Y., on or before November 26.

58-526 Properties of Octafluorocyclobutane—A Dielectric Gas. *F. W. Blodgett*

58-524 Overvoltage Protection and Maintenance Testing of A-C Rotating Machines. *H. R. Armstrong, J. E. Mulavey*

58-849 Sources of Electromagnetic Vibration in Single-Phase Induction Motors. *L. Magyar*

58-876 Electrical Features of the Upper Raquette River Power Project. *W. C. Van Dyke*

Preprints may be purchased at 40¢ each to members, 80¢ each to nonmembers, if accompanied by remittance or coupons. Please order by number and send remittance to: AIEE Order Department, 33 West 39th St., New York 18, N.Y.

AIEE Future Meetings

Magnetism and Magnetic Materials Conference*
Sheraton Hotel
Philadelphia, Pa.
November 17-20, 1958

AIEE-IRE-ISA Electrical Techniques in Medicine and Biology Conference*
Pick-Nicollet Hotel
Minneapolis, Minn.
November 19-21, 1958

AIEE-IRE-ACM Eastern Joint Computer Conference (Exhibit)*
Bellevue-Stratford Hotel
Philadelphia, Pa.
December 3-5, 1958

AIEE-IRE Second National Symposium on Communication Systems (Exhibit)*
Colonial Inn-Desert Ranch
St. Petersburg Beach, Fla.
December 3-5, 1958

AIEE-IRE-ASQC-EIA National Symposium on Reliability and Quality Control
Bellevue-Stratford Hotel
Philadelphia, Pa.
January 12-14, 1959
(Final date for †TP—closed, ‡CP Syn.—closed, CPMs—Nov. 7)

Winter General Meeting
Statler Hotel
New York, N. Y.
February 1-6 1959
(Final date for †TP—Nov. 3, ‡CP Syn.—Nov. 18, CPMs—Nov. 28)

AIEE-IRE-U of P Transistor and Solid-State Circuits Conference
University of Pennsylvania
Philadelphia, Pa.
February 12-13, 1959
(Final date for †TP—Nov. 13, ‡CP Syn.—Nov. 28, CPMs—Dec. 9)

AIEE-IRE-ACM Western Joint Computer Conference
Fairmont Hotel
San Francisco, Calif.
March 3-5, 1959
(Final date for †TP—Dec. 3, ‡CP Syn.—Dec. 19, CPMs—Dec. 29)

AIEE-ASME-IIT American Power Conference
Sherman Hotel
Chicago, Ill.
March 31-April 2, 1959
(Final date for †TP—Dec. 31, ‡CP Syn.—Jan. 16, CPMs—Jan. 26)

EJC Nuclear Congress
Municipal Auditorium
Cleveland, Ohio
April 5-10, 1959
(Final date for †TP—Nov. 28)

AIEE-ASME Railroad Conference
Chicago, Ill.
April 7-9, 1959
(Final date for †TP—Jan. 7, ‡CP Syn.—Jan. 23, CPMs—Feb. 2)

Southern District Meeting
Dinkler Plaza Hotel
Atlanta, Ga.
April 8-10, 1959
(Final date for †TP—Jan 8, DPMs—Feb. 2)

Electric Heating Conference
Bellevue-Stratford Hotel
Philadelphia, Pa.
April 14-15, 1959
(Final date for †TP—Jan 14, ‡CP Syn.—Jan. 30, CPMs—Feb. 9)

Electrical Problems in the Cement Industry Conference
Allentown, Pa.
April 16-17, 1959
(Final date for †TP—Jan. 16, ‡CP Syn.—Jan. 30, CPMs—Feb. 10)

Recording and Controlling Instruments Conference
Bellevue-Stratford Hotel
Philadelphia, Pa.
April 20-21, 1959
(Final date for †TP—Jan. 20, ‡CP Syn.—Feb. 3, CPMs—Feb. 13)

East Central District Meeting
Sheraton-Mayflower Hotel
Akron, Ohio
April 22-24, 1959
(Final date for †TP—Jan. 22, DPMs—Feb. 16)

Rubber and Plastics Conference
Sheraton-Mayflower Hotel
Akron, Ohio
April 22-24, 1959
(Final date for †TP—Jan. 22, ‡CP Syn.—Feb. 6, CPMs—Feb. 16)

Empire District Meeting
Hotel Syracuse
Syracuse, N. Y.
April 29-May 1, 1959
(Final date for †TP—Jan. 29, DPMs—Feb. 23)

AIEE-IRE-EIA-WCEMA Joint Electronic Components Conference
Benjamin Franklin Hotel
Philadelphia, Pa.
May 6-8, 1959
(Final date for †TP—Feb. 5, ‡CP Syn.—Feb. 20, CPMs—March 2)

AIEE-ASME-IRE Automatic Techniques Conference
Pick-Congress Hotel
Chicago, Ill.
May 11-13, 1959
(Final date for †TP—Feb. 10, ‡CP Syn.—Feb. 24, CPMs—March 6)

Middle Eastern District Meeting
Lord Baltimore Hotel
Baltimore, Md.
May 19-21, 1959
(Final date for †TP—Feb. 18, DPMs—March 13)

AIEE-ISA-ARS-IAS National Telemetering Conference
Brown Palace and Cosmopolitan Hotel
Denver, Colo.
May 24-27, 1959
(Final date for †TP—Feb. 23, ‡CP Syn.—March 10, CPMs—March 20)

Summer and Pacific General Meeting
Olympic Hotel
Seattle, Wash.
June 21-26, 1959
(Final date for †TP—March 23, ‡CP Syn.—April 7, CPMs—April 17)

Petroleum Industry Conference
Wilton Hotel
Long Beach, Calif.
August 25-27, 1959
(Final date for †TP—May 27, ‡CP Syn.—June 12, CPMs—June 23

AIEE-ASME Engineering Management Conference
Los Angeles, Calif.
September 16-18, 1959
(Final date for †TP—June 18, ‡CP Syn.—July 3, CPMs—July 13)

Magnetic Amplifiers Conference
Shoreham Hotel
Washington, D. C.
September 23-25, 1959
(Final date for †TP—June 25, ‡CP Syn.—July 10, CPMs—July 20)

Fall General Meeting
Morrison Hotel
Chicago, Ill.
October 11-16, 1959
(Final date for †TP—June 12, ‡CP Syn.—July 30 CPMs—Aug. 7)

*Final date for submitting papers—closed
†TP—Transactions Paper
‡CP Syn.—Conference Synopsis
CPMs—Conference Manuscript
DPMs—District Manuscript
(District Paper Synopses should be directed to the District Meeting Committee)

Transactions and conference papers must conform to the requirements in *Authors Guide*. For a copy, write to E. C. Day, AIEE, 33 W. 39th St., New York 18, N.Y.

unless the dielectric losses could be successfully reduced, because of possible thermal instability. Therefore, when the problem of making a cable for 220-kv working tension arose, he recognized the necessity of reducing the dielectric losses, and solved the problem by developing the so-called low loss washed paper for the insulation. This permitted the realization in 1932 of an experimental 220-kv cable installed in connection with a 220-kv aerial line belong to Società Idroelettrica Piemonte, and later to the important 220-kv cable line installed in Paris and inaugurated by Messrs. Inter-Paris on March 23, 1936.

In addition to his interests in high voltage cables, Mr. Emanueli's activities have also been directed to telecommunication cables.

In 1910, following theoretical and experimental investigations carried out in the laboratory, he designed a telephone cable made up of a pair of continuously loaded copper conductors (Krarup), paper insulation, and a lead sheath.

This cable, more than 100 miles long, and the longest telephone cable in the world at that tme, was manufactured by the Pirelli Company and put into service as an aerial cable between Milan and the Grossotto Hydroelectric Power Station during the same year.

In 1913, Mr. Emanueli was called upon by the Italian Post Office authorities to design a submarine telephone cable which was to be laid between Sardinia and Continental Italy. After many tests, he found that it was necessary, in order to increase the transmitting distance, to improve the return circuit by the application of a layer of copper wires over the insulated core. This was confirmed by others, and is now common practice in submarine telephone cables.

Later and more recent developments devised by Mr. Emanueli are well known to those interested in the cable art.

Bimonthly Publications

The bimonthly publications, *Communication and Electronics, Applications and Industry*, and *Power Apparatus and Systems*, contain the formally reviewed and approved numbered papers presented at General and District meetings and conferences. The publications are on an annual subscription basis. Members may receive one subscription to any *one* of the bimonthlies for $2.50. The balance of the annual $5.00 subscription price will be paid by application of his annual dues for the year of the subscription. (Members may not reduce the amount of their dues payment by reason of nonsubscription.) Additional member subscriptions will be at the rate of $5.00. Nonmembers may subscribe on an advance annual subscription basis of $8.00 each (plus 50¢ extra for foreign postage payable in advance in New York exchange). Single copies, when available, are $1.50 each. Discounts are allowed to libraries, publishers, and subscription agencies.

Board of Directors Meeting
August 21, 1958, Sacramento, Calif.

THE FIRST meeting of the AIEE Board of Directors, for the administrative year 1958-59, was held in connection with the 1958 Pacific General Meeting in Sacramento, Calif. on Thursday, August 21, 1958. Of the authorized 34, 25 were present. The Board meeting was preceded by meetings of the Constitution and Bylaws and the Planning and Co-ordination Committees on Wednesday.

Appropriate actions were taken expressing the Board's respects and sympathy on the deaths of Past-President Harold W. Buck and Chairman W. B. Morton of the Administration Department.

The Treasurer reported a cash balance of $417,573.56 in the General Fund as of July 31, and a book value of the Reserve Capital Fund of $1,121,076.90. The prompt mailing of the dues bills and the machine tabulation of receipts resulted in the banking of $100,000 more in the first three months of this fiscal year, than in the same period last year. It is important that collections continue this way, if a high delinquency rate is not to be experienced in this first year when dues payments must be made by October 1. AIEE members have, heretofore, had a whole year in which to pay their dues. The habit of waiting until the last few months of the year may take a while to break.

A number of actions were taken clarifying the appointment and tenure of committees. The most significant of these was the delegation of full authority to the Executive Committee to act for the Board, as provided in section 44 of the Constitution, and the provision that the Board will consequently hold only three regular meetings each year, rather than the customary five. The three regular Board Meetings will be held in connection with the Fall, Winter, and Summer General Meetings. Progress was indicated in the revision and modernization of the Constitution. Several matters of principle were clarified.

The 75th Anniversary Committee was enlarged and given an expanded charter to implement and co-ordinate a program which it had previously designed. This program calls for the participation of all units of the Institute in a year-long observance of the 75th birthday of the Institute.

A feature of this Board meeting was the appearance of President J. N. Landis of the American Society of Mechanical Engineers (ASME), to discuss with the AIEE Board, the ASME position with respect to the AIEE Functional Plan for effective intersociety co-operation. ASME has endorsed the Functional Plan in principle, but proposes the incorporation of its major features into one over-all "American Engineering Association." This "AEA" would include Engineers Joint Council (EJC), Engineers' Council for Professional Development (ECPD), and National Society of Professional Engineers (NSPE), as well as the present EJC and ECPD constituents. It would be a federation of societies in which the three components of the Functional Plan would be the major operating divisions.

In the hope of bringing to bear on the development of further intersociety co-operation, the thoughts and desires of a broader segment of the membership of the Founder Societies and NSPE, the AIEE Intersociety Relations Committee submitted its "Report #3" which was approved by the Board. This report calls for the encouragement and stimulation of participation by the Sections of the Founder Societies and the state and local professional engineering societies in the study of this problem. The report also provides for a questionnaire to the Members and Fellows of AIEE seeking their personal reaction to the suggestion that NSPE open its membership to nonregistered mature and able engineers as identified by the upper grades of Founder Society membership. Whether or not those who are not now members of NSPE, but qualified under this proposal, would join and support the professional objectives of the Functional Plan through NSPE is considered an important element in the feasibility of the Functional Plan.

Further in the field of intersociety relations, the Board approved the EJC Articles of Incorporation, and endorsed an EJC plan to form a National Transportation Policy study group in the hope that a significant contribution could be made in this field as was done by the National Water Policy Panel. Mr. W. J. Barrett was appointed to fill the unexpired term of the late Walter B. Morton as an alternate member of the EJC Board of Directors. The "Memorandum of Organization" of EUSEC, as adopted at the May 2, 1958, Conference of Engineering Societies of Western Europe and United States, was approved by the Board. Other recommendations of the EUSEC Conference were likewise approved.

Nine Fellows were elected. Some of their biographies will be found in this issue of *Electrical Engineering*. The rest will appear in a future issue.

Action was taken calling for the revision of the ECPD Charter to establish criteria and procedures for the addition of suitable constituent societies to that body. Nominations for AIEE representatives on ECPD Committees were approved.

It was announced that Dr. Luigi Emanueli, vice-chairman of the board and consulting engineer, Pirelli SPA, Milan, Italy, had been elected an Honorary Member of AIEE. Presentation of the Certificate of Honorary Membership to Dr. Emanueli will be made by a committee of AIEE members in Milan.

The next meeting of the Board was to be held on Friday October 31, 1958, at the Fall General Meeting.

Papers Presented at the 1958 AIEE Pacific General Meeting

A LISTING of the papers presented at the 1958 Pacific General Meeting of the Institute, held August 19-22, in Sacramento, Calif., follows. Copies of numbered papers are available to members for 40¢ each and to nonmembers for 80¢ each. Send order and remittance to: AIEE Order Department, 33 W. 39th St., New York 18, N. Y. Papers marked CP* have not been printed by the Institute.

Tuesday, August 19

2:00 p.m. Relays and Rotating Machinery

58-1018. Protection of Three-Phase Motors against Single-Phase Operation. *L. L. Gleason*, City of Seattle Lighting Dept.; *W. A. Elmore*, Westinghouse Electric Corp.

58-1019. Drainage Reactor Protection of Pilot Wire Circuits. *J. G. Hendrickson, A. R. Caprez*, City of Tacoma Dept. of Public Utilities.

58-1020. Contribution to the Theory of Commutation on D-C Machines. *R. Holm*, Stackpole Carbon Co.

CP.* A New Brushless Alternator with Electromagnetic Excitation. *H. M. Robinson, F. B. McCarthy*, Aerojet-General Corp.

2:00 p.m. Computing Devices

58-1003. Direct System Synthesis by Means of Computers. *A. B. Clymer*, North American Aviation, Inc.

CP58-1046. Servo Controlled Magnetic Tape Delay Line. *L. J. Kamm*, Convair.

CP.* Logic for Magnetic Tape Delay Line. *D. N. Hale*, Convair.

CP.* The Logical Design of a Serial General-Purpose Computer with Micro-Programming Capabilities. *R. I. Tanaka*, Lockheed Aircraft Corp.

CP58-1025. Matrix Synthesis of High-Speed Logic. *E. J. Schubert*, Burroughs Corp.

2:00 p.m. Power Generation

58-769. Performance of Generator Thrust Bearings at Hoover Power Plant. *F. B. Looper*, City of Los Angeles Dept. of Water and Power.

58-1024. Electrical Requirements of Reversible Pumped-Storage Units. *H. H. Roth*, Allis Chalmers Mfg. Co.

CP58-1043. The Impact of Atomic Energy on Water Resources Development. *F. J. Groat*, California Department of Water Resources.

CP58-1042. Motor-Driven vs Shaft-Driven Exciter Tests. *S. H. Gold, C. K. Grant, J. H. Zornes*, California Electric Power Co.

Wednesday, August 20

9:00 a.m. Industrial Power Systems

CP58-1034. Power Distribution in Agglomerating Plants. *J. E. Barkle, L. W. Soden*, Bechtel Corp.

CP58-1078. Industrial Power System Design at 480 Volts. *C. L. Phillips*, General Electric Co.

CP58-1048. Performance Testing of Emergency Power Supplies for a Nuclear Reactor. *W. R. Moon*, General Electric Co.

CP.* Application of Low-Voltage Air Circuit Breakers to Modern Industrial Plants. *R. I. Carlson, I. C. Fisk*, Allis-Chalmers Mfg. Co.

9:00 a.m. Nucleonic and Radiation Instrumentation

CP.* The Sodium Reactor Experiment. *J. E. Owens*, Atomics International.

CP58-706. Instrumentation for a Boiling Water Reactor. *L. Kornblith, Jr.*, General Electric Co.

CP.* Analytical Methods for Determining Control Requirements for Nuclear Power Plants. *E. B. Ash, J. G. Lundholm, Jr.*, Atomics International.

CP.* Data Handling Systems for Nuclear Power Plant. *T. R. Hudson*, Daystrom Systems.

9:00 a.m. Domestic and Commercial Applications

58-1006. Tramp-Iron Remover for a Field Forage Harvester. *F. C. Jacob, J. B. Dobie*, University of Calif.

CP.* Electrical Design for Fire Safety in Hospital Operating Rooms. *R. E. Carlson*, State Fire Marshall Office.

58-1007. Artificial Cooling of Livestock in Hot Climates. *C. F. Kelly*, University of Calif., *T. E. Bond*, U. S. Dept. of Agriculture, and *N. R. Ittner*, (deceased).

CP58-1000. Reversible Electrical Distillation by Use of Transthermer. *R. C. Schlichtig*, Seattle, Wash.

58-1010. Earth Source Heat Pumps, Characteristics, Design, and Operation. *E. A. Freund, G. S. Whitlow*, Union Electric Co. of Missouri. (Re-presented for Discussion only.)

2:00 p.m. Industrial Power Systems

CP58-1015. An Experience Report on the Use of Aluminum Wire and Cable in Industrial Plants. *H. Esch*, Kaiser Aluminum & Chemical Corp.

CP58-1035. Portable Power Supply for Movie Studio Service. *P. Belsky*, Westinghouse Electric Corp.; *G. Feldcamp*, Walt Disney Productions.

CP.* Power Systems for Emergency Lighting. *A. B. Smedley*, Pasadena, Calif.

2:00 p.m. Insulated Conductors

CP58-1016. History and Development of Residential Underground Distribution in Southern California. *R. C. Blankenburg*, Southern California Edison Co.

CP58-1017. Heat Run Testing of Pipe-Type Cable. *C. M. Buck, F. B. Schullerls*, Pacific Gas & Electric Co.

2:00 p.m. Space Heating

CP58-1001. Solar House Heating. *W. A. Danielson*, Brig. Gen. U.S.A., Ret., Memphis, Tenn.

CP58-1011. Boolean Algebra Applied to Heat Pump Design. *H. P. Gluckman*, Los Angeles Dept. of Water and Power; *G. J. Friedman*, Servomechanisms, Inc.

58-1012. Residential Heating—Electric vs Gas or Oil. *G. S. Smith*, University of Wash.

CP58-1013. Centrifugal Heat Pump System for Service Center. *J. A. Wright*, The Washington Water Power Co.

58-1014. Motor-operated Switch for Space Heating Control. *J. C. Beckett*, Wesix Elec. Heater Co. (Re-presented for Discussion only.)

Thursday, August 21

9:00 a.m. Feedback Control Systems

58-1002. A Phase Plane Approach to Relay Sampled-Data Feedback Systems. *F. J. Mullin, E. I. Jury*, University of Calif.

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CP.* Applications of Continuous System Design Concepts to Sampled Data Systems. *S. F. Schmidt*, Ames Aeronautical Laboratory.

CP58-1026. Relay Type Feedback Control Systems with Dead Time and Sampling. *K. Izawa*, Purdue University; *L. E. Weaver*, University of Arizona.

CP.* Least Squares Design of Multivariable Control Systems. *R. C. Amara*, Stanford University.

9:00 a.m. Management, Research, and System Engineering

58-1030. Economic Selection of Generating Capacity Additions. *T. W. Schroeder, G. P. Wilson*, Illinois Power Co.

CP58-1031. Managing Research Laboratories. *T. M. Linville*, General Electric Co.

9:00 a.m. Radio Communication Systems

58-181. A 6,000-Mc Radio System for Toll Telephone Service. *M. H. Kebby, A. F. Culbertson*, Lenkurt Electric Co. (Re-presented for Discussion only.)

CP58-1047. Expansion of Pacific Coast Microwave Network. *R. G. Kuck*, Pacific Telephone & Telegraph Co.

CP.* A New Flexible Radio System for Traffic Light Control. *C. Willyard*, Motorola, Inc.

CP58-1038. Put the Tip of Your Finger to Work. *H. H. Davids*, General Electric Co.

CP.* Atmospheric Influences on 36 Kilomegacycle Propagation. *W. Flock*, National Bureau of Standards and University of California.

2:00 p.m. Feedback Control Systems

58-1027. Complex-Zero Signal Generator for Rapid System Testing. *G. G. Lendaris, O. J. M. Smith*, University of California.

58-1028. Servo Motor Theory: Effect of Planning Source Impedance on Motor Performance. *A. Diamond*, Ketay Dept. of United Aircraft Corp., formerly of Helipot Corp.

CP58-89 Application of Switching Transistors and Saturable Reactors in a High-Performance Servo. *F. B. Cox, Jr., P. R. Johannessen*, Massachusetts Institute of Technology.

2:00 p.m. Wire Communication Systems

CP.* The Underwater Voiceway to Hawaii. *J. W. Dunbar*, American Telephone and Telegraph Co.

CP.* Field Experience with the *B-510* Type Carrier System. *W. E. Noller*, Lynch Carrier Systems, Inc.

58-1004. Type *OJ* Carrier Telephone System. *J. A. Coy*, ret. Bell Telephone Laboratories, Inc.; *E. S. Kelsey, B. T. Nicholls*, Northern Electric Co. Ltd.

58-1005. The *"ON/K"* Carrier System. *G. T. Masters*, Pacific Telephone & Telegraph Co.

Friday, August 22

9:00 a.m. Substations

58-1008. Zig-Zag Configuration in High-Voltage Ring-Bus Substation. *R. N. Connelly*, Sacramento Municipal Utilty District; *R. F. Gibbons*, Federal Pacific Electric Co.

58-1021. Requirements for, and Operating Experience with, Supervisory Control on the Bonneville Power Administration System. *J. R. Boston, K. E. Shank*, Bonneville Power Administration.

CP58-1022. Report on West Coast Practices for Transil Oil Handling in Substations. AIEE Working Group on Project 56.2, J. L. Buckley, Chairman.

58-22. The Insulator Contamination Problem as Influenced by Silicone Surface Coatings. *J. E. Conner*, Southern California Edison Co.; *A. D. Lantz, Jr.*, The Ohio Brass Co. (Re-presented for Discussion only.)

9:00 a.m. Transmission and Distribution

58-1025. Nodal Representation of Large Complex-Element Networks Including Mutual Reactances. *J. C. Siegel, G. W. Bills*, North American Aviation, Inc.

58-360. The Magnetic Properties of ACSR Core Wire. *L. W. Matsch*, University of Arizona; *W. A. Lewis*, Illinois Institute of Technology.

CP58-1009. Graphical Analysis of Aerial Cable Current Characteristics. *E. Hazan*, Kaiser Aluminum & Chemical Corp.

58-1029. The Resistance and Reactance of Aluminum Conductors, Steel Reinforced. *W. A. Lewis*, Illinois Institute of Technology; *P. D. Tuttle*, Alcoa Research Laboratories.

CP.* Rapid Determination of Corona Loss from Voltage—Charge Diagrams. *H. S. Dixon*, Berkeley, Calif.

National Conference Held on Application of Electrical Insulation

AMERICA is getting the electrical insulation it needs to meet today's ultrahigh temperature requirements because new plastics, chemicals, and other materials are successfully being combined with traditional insulators, the National Conference on the Application of Electrical Insulation was told during its meeting held September 3-5, 1958, in Cleveland, Ohio.

This was the first national meeting of this type ever held in the United States. Participating were representatives of manufacturers of insulating materials and users, both civilian and military.

The Conference, co-sponsored by the AIEE and the National Electrical Manufacturers Association (NEMA), held its sessions at the Statler-Hilton and Pick-Carter hotels.

In a technical paper prepared for presentation at a session on September 3, Allen Hubbard III, of The Lewis Engineering Company, said that suitable insulating materials and systems are currently available, which, "with careful attention to application and location, can satisfy nearly all of the service requirements for modern day aircraft and those proposed for the immediate future."

Sealed oil-filled transformers that can operate at 105 C "for at least 20 years" are possible by using polyvinylchloride lead insulation with stabilizers, according to a paper prepared by W. T. Berry, Jr., and T. L. Sherer, General Electric Company. The material showed no loss of dielectric (insulating) strength after accelerated tests, they said.

Wire manufacturers told how the trend toward miniaturization affected them. "The general trend in everything we do and make today is toward smaller and smaller units," G. C. Martin and R. O. Weisz, Essex Wire Corporation, stated.

E. L. Smith and G. D. Hilker, Phelps Dodge Copper Products Corporation, Inca Manufacturing Division, said that "In order to design for miniaturization, insulations capable of withstanding higher temperatures were demanded." Of the "millions of miles of copper wire" consumed annually by the American electronics industry, they said that the major portion was of less than 10 mils in diameter, and that hearing aids, instruments, and control devices in some cases required wire as fine as 0.6 mils in diameter.

The rapid increase in the past 2 years in the use of epoxy glass fabric laminated materials as a base for printed circuits such as those used "in the maze of electronic equipment that plays such a big part in this age of guided missiles," was described in a paper by A. J. Green, J. C. Pesce, and R. F. Bogart, National Vulcanized Fibre Company. The majority of printed circuit applications, however, can be satisfied by the use of copper clad laminates, St. John Bain, Formica Corporation. Division of American Cyanamid Corporation, stated.

Although synthetic products are now widely used to insulate and cool transformers, the petroleum industry expects to sell more than 55 million gallons of transformer oil in 1958, S. C. Bartlett, Jr., Sun Oil Co., stated. Oil has been used for this purpose for 60 years. Mr. Bartlett said that the practical life of transformer oil runs from 20 to 30 years, may be even extended to 40 years.

Martin Wolff, Chicago Standard Transformer Corporation, presented some of the aspects of the use of silicone insulating materials in the development and manufacture of transformers for use in the electronics field.

Motors insulated with materials derived from sand which have a theoretical lifetime of "over 1,000 years," were described during a session on September 4 by L. J. Stage, Electro-Technical Products Division, Sun Chemical Corporation.

The glass cloth used in today's high-temperature (Class H) insulation is made from "sand, silica, the very same basic ingredient going into window glass used in your homes," Mr. Stage said. The resins that are used to coat it, he said, are "silicone varnish, fully cured and semicured silicone elastomers, polyfluoroethylene and polyfluorochloroethylene resin dispersions. Like glass fabric, the silicones depend on sand as a starting material."

Glass fabrics were also commended by L. N. Smith, of the New Jersey Woodfinishing Company.

R. W. Staley and J. S. David, General Electric Company, reported that mica mat, a relatively new insulating material which is made from mica flakes, is being successfully used on rotating equipment.

Continuous services of cast films made from tetrafluoroethylene resin at 500 F, "as well as use at temperatures of —450 F with no embrittlement," were reported by J. V. Petriello, of the Dilectrix Corporation.

In contrast, S. W. Pease, Crocker, Burbank & Co. Assn., described how one of man's oldest products—paper—is still widely used.

Mr. Stage, in a second paper, dealt with flexible insulation for transformers, and

pointed out the outstanding properties of the newer plastic films, such as cellulose acetate, cellulose tri-acetate, polyester films, vinyl when used with papers, fabrics and nonwoven cloths for electrical insulation.

Natural mica was described as "industry's most perfect electrical insulating material" in a paper prepared by J. F. Buffalino and E. L. Kelly of The Huse-Liberty Mica Company.

Gases used as insulation were described by Dr. F. L. Holloway and Dr. W. H. Mears, General Chemical Division, Allied Chemical Corporation, and F. W. Blodgett, E. I. Du Pont de Nemours & Co. (Inc.).

An ancient area of electrical insulation—encapsulation—has been revitalized with the advent of guided missiles, computers, transistors, and other modern devices.

At one time tallow and beeswax were used to surround completely electrical components to provide insulation, protection, hermetic sealing, or for making them more rugged. Today, things are more complicated.

Several authorities in the field of potting and encapsulating discussed the subject at the final sessions of the 3-day Conference.

W. R. Cuming, Emerson & Cuming, Inc., described the use of hollow glass microspheres, particles so small that they are measured in microns—one micron being one-millionth of a meter.

C. W. Jenner, Houghton Laboratories, Inc., described encapsulating mediums for apparatus ranging in size "all the way from a tiny corn kernel transformer up to high voltage power bushings." Traditionally, oils, waxes, polyesters, and bituminous compounds have been used, but since 1946, "the epoxy resins have become increasingly important," he said.

Vacuum potting—to get air bubbles or trapped moisture out of the encapsulating unit—has been introduced, and the process was described by J. L. Hull, Hull-Standard Corporation.

Water—in the form of moisture—is an important problem in the operation of a-c induction motors aboard nuclear submarines, and H. P. Walker, Bureau of Ships, United States Navy Department, and R. J. Fisherty, Jr., United States Naval Engineering Experiment Station, presented a paper outlining results of intensive 90-day humidification tests on different insulation systems.

How nylon is used in atomic-powered submarines was described in a paper prepared by W. C. Wall, E. I. du Pont de Nemours & Co. (Inc.).

Six papers on silicones were presented on September 5. D. M. Bartos, Dow Corning Corporation, described the properties and applications of silicone rubber insulation systems, and L. A. Teichthesen, of the same company, discussed the use of silicone varnishes on transformers.

"Silicones are not wonder materials," J. S. Hurley, Jr., and E. C. Bobe, General Electric Company, said in a paper on silicone varnishes for electronic applications, "but when properly applied, will provide performance which will assure the reliability you need to develop your piece of apparatus as a leader in the electronic industry." C. A. Berridge and J. S. Hurley, Jr., of the same company, described a new type of silicone rubber that will cure at room temperature, which was said to be "ideal for in-place sealing of high temperature aircraft and missiles, and for potting and encapsulating electronic equipment to provide mechanical and electrical protection.

T. J. Mahoney, Silicones Division, Union Carbide Corporation, described silicone dielectric fluids for electrical components.

Eight different ways in which silicon resins are now employed in electrical insulation were listed by A. J. Wiltjer, of the same corporation.

Houston Section Celebrates Anniversary

COMPLETION of the 30th Anniversary of the AIEE Houston Section was celebrated by the Section with a banquet for members and their wives. The Houston Section was organized in 1928 and the completion of the 1957-58 year marked the end of 30 years of growth which has been 14 fold. Of the 30 past chairmen, 16 were in attendance. Shown (*front row, left to right*) are: L. K. Del Homme, C. S. Williams, Jr., N. F. Rode, E. G. Westheimer, W. O. Ray, (*back row, left to right*) M. T. Robin, V. O. Clements, Hazzie Clark, T. M. Keiller, H. P. Heafer, J. B. Arthur, P. H. Robinson, W. E. Silvus, H. L. Miller, E. M. Wise, and T. A. Standish.

Officers To Be Nominated for 1958 Institute Election

For the nomination of officers to be voted upon in the Spring of 1959, the AIEE Nominating Committee will meet in New York, N. Y., February 2, 1959. The officers to be elected are: a President, a Treasurer, three Directors, and six Vice-Presidents, one from each of the even-numbered geographical Districts. Fellows only are eligible for the office of President; Members and Fellows for the offices of Vice-Presidents, Directors, and Treasurer.

To guide this Committee in performing its constituted task, suggestions from the membership are, of course, highly desirable. To be available for consideration of the Committee, all suggestions must be received by the Secretary of the Committee at Institute headquarters, not later than December 15, 1958.

In accordance with the provisions in the Constitution (C) and Bylaws (B), quoted in the following paragraphs, actions relating to the organization of the Nominating Committee are now under way:

Constitution

C-30 There shall be constituted each year a Nominating Committee consisting of one representative of each geographical District, elected by its Executive Committee, one representative of each technical division elected by the division committee, and other members chosen by and from the Board of Directors, not exceeding in number the number of technical divisions; all to be selected when and as provided in the Bylaws. The Secretary of the Institute shall be the Secretary of the Nominating Committee, without voting power.

C-31 The Executive Committee of each geographical District shall act as a Nominating Committee of the candidate for election as Vice-President of that District, or for filling a vacancy in such office for an unexpired term, whenever a vacancy occurs.

C-32 The Nominating Committee shall receive such suggestions and proposals as any member or group of members may desire to offer, such suggestions being sent to the Secretary of the committee.

The Nominating Committee shall name one or more candidates for President, Treasurer, and the proper number of Directors, and shall include in its ticket such candidates for Vice-Presidents as have been named by the Nominating Committees of the respective geographical Districts, if received by the Nominating Committee, when and as provided in the Bylaws; otherwise, the Nominating Committee shall nominate one or more candidates for Vice-President(s) from the District(s) concerned.

Bylaws

B-27 During September of each year, the Secretary of the Nominating Committee shall notify the Chairman and Secretary of the Executive Committee of each geographical District, and the Chairman and Secretary of each

Technical Division Committee, that by December fifteenth of that year, each District and each Technical Division should select a representative to serve as a member of the AIEE Nominating Committee. The names of representatives and alternates, so selected, should be transmitted by the above designated officers to the Secretary of the Nominating Committee by December fifteenth.

During September of each year, the Secretary of the Nominating Committee shall notify the Chairman and Secretary of the Executive Committee of each geographical District in which there is, or will be during the year, a vacancy in the office of Vice-President that by December fifteenth of that year, a nomination for a Vice-President in that District made by the District Executive Committee should be in the hands of the Secretary of the Nominating Committee.

Between October first and December fifteenth of each year, the Board of Directors shall choose a number of its members, not exceeding the number of technical divisions, to serve on the Nominating Committee, and notify the Secretary of the Nominating Committee of the names of the members so chosen.

The Secretary of the Nominating Committee shall give the members so selected not less than 10 days' notice of the first meeting of the committee, which shall be held not later than February fifteenth. At this meeting, the committee shall elect a chairman and shall proceed to make up a ticket of nominees for the offices to be filled at the next election. To insure that full consideration be given to all suggestions from the general membership, they must be in the hands of the Secretary of the committee by December fifteenth. The nominations as made by the Nominating Committee shall be published in the April issue of *Electrical Engineering*, or otherwise mailed to the Institute membership not later than the last week in March.

Independent nominations may be made in accordance with provisions in C33, of the Constitution and B28 of the Bylaws, which are quoted in the following:

Constitution:

C-33 Independent nominations may be made by the petition of twenty-five (25) or more corporate members sent to the Secretary when and as provided in the Bylaws; such petitions for the nomination of Vice-Presidents shall be signed only by members within the District concerned.

B-28 Petitions proposing the names of candidates as independent nominations for the various offices to be filled at the ensuing election, in accordance with C33 (Constitution), must be received by the Secretary of the Nominating Committee not later than March fifteenth of each year, to be placed before that committee for the inclusion in the ballot of such candidates as are eligible.

28.1 The candidates shall appear on the ballot, grouped alphabetically under the name of the office for which each is a candidate. The voting in each case shall be restricted to the nominees printed on the ballot. The ballot shall be mailed to the membership by April 15.

28.2 The ballot shall provide a place where the entire slate of nominees can be voted with a single mark, if there is no choice to be made between any of the candidates. The balloting should be secret in the case of a contest. The ballots shall be checked for ineligible voters only in the case of a contest.

28.3 The Tellers' Election Report shall give the sum total of the ballots received and shall designate this total as a vote for the entire slate of officers where there are no alternative candidates. Only in the case of a contest shall an individual count be made.

28.4 The President shall decide the number of Tellers for each election. The Secretary is authorized to prepare the ballot for counting on a business machine where feasible.

(signed) *N. S. Hibshman*
Executive Secretary

Committee Heads for Western Joint Computer Conference Named

Committee heads have been named for the 1959 Western Joint Computer Conference to be held in San Francisco, Calif., March 3-5.

Joint sponsors are the AIEE, Institute of Radio Engineers, and Association for Computing Machinery. Headquarters and meeting place will be the Fairmont Hotel.

R. R. Johnson of the General Electric Computer Laboratory, Palo Alto, Calif., is general chairman and has announced the composition of the steering committee for the Conference, all Californians, as follows:

R. W. Melville, Stanford Research Institute, Menlo Park, vice-chairman and chairman of the technical program; Charlie Asmus, General Electric Computer Laboratory, Palo Alto, Conference secretary-treasurer; B. J. Bennett, IBM Product Development Laboratories, San Jose, publications; G. A. Barnard, III, Ampex Corporation, Redwood City, publicity; H. K. Farrar, Pacific Telephone & Telegraph Co., San Francisco, exhibits; K. F. Tiede, University of California Radiation Laboratory, Livermore, field trips; R. M. Bennett, Jr., IBM Research Laboratory, San Jose, registration; L. D. Krider, University of California Radiation Laboratory, Livermore, printing; Mrs. Joanne Teasdale, General Electric Computer Laboratory, Palo Alto, women's activities; E. T. Lincoln, Stanford Research Institute, Menlo Park, mailing; and R. C. Douthitt, Remington Rand, El Cerrito, local arrangements.

Incorporation of Engineers Joint Council

Acceptance of the Articles of Incorporation, granted Engineers Joint Council (EJC) by the Secretary of State, New York, on March 20, 1958, has been voted by the majority of the member societies of EJC. On July 10, the incorporation of EJC was formalized at a special meeting of the Board of Directors and EJC became a membership corporation. Corporate officers elected included: President—E. R. Needles; Vice-President—O. B. J. Fraser; Treasurer—E. L. Chandler; Secretary—E. P. Lange; Assistant Secretary—L. K. Wheelock.

Commenting upon the change of EJC from a voluntary unincorporated association to its corporate status, President Needles said: "The incorporation of Engineers Joint Council strengthens the activities of EJC by presenting a more solid and formal organization than hitherto. It is a definite step toward unity in the engineering profession and the actions of EJC as a 'legal person' will carry the added weight of a homogeneous group."

At the July 10th meeting, the Board of Directors confirmed the election of the American Institute of Plant Engineers as an associate member, effective July 10. This brings the number of societies in EJC to 19.

AT A RECENT MEETING of the AIEE Hawaii Section were: (left to right) J. F. Richardson, Jr., chairman of the AIEE Hawaii Section; T. H. MacCauley, guest speaker; L. W. Leugnick, executive engineer, Hawaiian Electric Company, Ltd.; and W. D. McKernon, secretary-treasurer of the Hawaii Section.

T. H. MacCauley Addresses Hawaii Section of the AIEE

T. H. MacCauley, a member of the Institute's Public Relations Committee and chairman of the Philadelphia Section's Radio Committee, was guest speaker at the Hawaii Section's Technical Session Meeting held August 26, 1958.

During his discussion, entitled "The Scientists and Engineers are the Pacemakers of Modern Life," Mr. MacCauley presented playbacks of broadcasts from the Philadelphia Section's radio program "Meet the Engineer" recorded by guests concerned with the great technological advances of modern times in outer space.

The interest shown by members attending the meeting resulted in plans for

broadcasts to be presented on "Meet the Engineer" during December entitled "Hawaii's Four-Dimensional Boom—Electricity, Industry, Military, and Leisure Time." These radio broadcasts will be recorded by the top executives of the Hawaiian Electric Company, Ltd., and (Dole) Hawaiian Pineapple Company, Ltd., in co-operation with the chairman of the Hawaii Section of AIEE, J. F. Richardson, Jr. The moderator will be Mr. MacCauley.

THE COLONIAL INN on St. Petersburg Beach, Fla., will be convention headquarters for the Second National Symposium on Global Communications to be sponsored by AIEE and IRE December 3-5, 1958.

Florida's Gulf Coast Selected for Communications Symposium

The Second National Symposium on Global Communications (GLOBE-COM II) jointly sponsored by the AIEE Communications Division and the Institute of Radio Engineers (IRE) Professional Group on Communications Systems, will be held December 3-5, 1958, at two adjoining resort hotels, the Colonial Inn and the Desert Ranch, situated on the Gulf of Mexico at St. Petersburg Beach, Fla. The technical program will include 60 papers by internationally recognized experts, covering the latest advances in radio and wire communications; data link systems; spectrum utilization, conservation, and administration; system reliability; application and utilization of military and civil systems; etc.

Those attending will meet many of their co-workers who specialize in global communications and will enjoy an exceptional opportunity to exchange views on the problems arising in their field.

Of the leading manufacturers of communications equipment, 54 will exhibit their latest products for the benefit of the registrants at GLOBE-COM II.

By special arrangement, luxurious accommodations will cost only $5 to $6 per person per day for double occupancy of twin-bed rooms.

There will be a formal banquet and a formal luncheon. The banquet address will be delivered by D. G. Fink, president of IRE. Harry Davis, technical director of the Rome Air Development Center, will be the luncheon speaker.

Those who wish to attend and who did not receive a registration form mailed during October may write to the chairman of the Registration Committee, T. F. Thompson, Jr., Florida Power Corporation, P.O. Box 4042, St. Petersburg, Fla.

The formal banquet on December 4 at the Colonial Inn will cost $7.50; the formal luncheon, also at the Colonial Inn, on December 3, $3.50; and the cocktail party, scheduled for December 3 at the Desert Ranch, will cost $5.00. Prices for unassembled meals will be correspondingly low.

Chairmen of the various committees are: Technical Program: M. E. Donaldson, Electronic Communications, Inc. (ECI); Exhibits: R. E. Lazarchik, Sperry-Rand Corp.; Registration: T. F. Thompson, Jr., Florida Power Corporation; Local Arrangements: Rocco Griesi, ECI; Publicity: Leslie Spencer, ECI; Finance: D. E. Knauss, Florida Power Corporation; and Ladies Program: Mrs. G. E. Reynolds, Jr.

Members of the Steering Committee are: E. N. Dingley, Jr. (IRE general chairman) ECI; I. L. Garcia (AIEE general chairman) Florida Power Corporation; M. R. Donaldson, ECI; P. R. Gibbons, Tampa Electric Co.; R. E. Raymond, Florida Power Corporation; and E. L. White, consulting engineer.

The ladies' program will provide something to do every minute, or, if preferred, the ladies can swim in the Gulf or in either of the two fresh-water pools without charge, bask in the sun, and enjoy the western coast of Florida on their own. Also, there will be a special luncheon for the ladies on December 4 at the Desert Ranch. Deep-sea fishing trips and other activities can be arranged at moderate cost.

AIEE Kansas City Section Sponsors Public Lecture Series

This Fall, the Kansas City Section of the AIEE is offering to the general public a series of four lectures on the "Science of Electricity." Directed toward the layman, the high school student, and the teacher, the lecture series is designed to present a basic course in electricity.

The two lectures presented during October were:

October 10, 1958. Electricity: An introduction to the Science of Electricity, its history and basic concepts. Speaker: Prof. R. M. Kerchner, head of the department of electrical engineering, Kansas State College, Manhattan, Kans.

October 24, 1958. Communications: The communications systems of the country, their place in your everyday life, and their present and future functions in national defense. Speaker: L. M. Hartwell, fundamental plans engineer, American Telephone & Telegraph Company.

The lectures planned for November, both to be held at 8:00 p.m. in the Linda Hall Library, will be:

November 7, 1958. Electronics: Electronics is an important part of our daily lives. A discussion of the many ways it lightens our labor, contributes to our pleasure, and provides defense for the nation. Speaker: Dr. J. N. Warfield, associate professor of electrical engineering, University of Kansas, Lawrence, Kans.

November 21, 1958. Power: The generation and transmission of power has become a necessity in the life and economy of our nation. The power systems of the country and the need and future of nuclear generation will be discussed. Speaker: C. M. Lytle, manager of operations, Kansas City Power & Light Company.

The Section's Science Lecture Committee includes: Chairman S. H. Pollock, W. R. Wheeler, R. W. Kunkle, and C. M. Lytle.

AIEE FELLOWS ELECTED

Board of Directors Meeting, August 21, 1958

Ernest Albert Johnson (AM '35, M '44), vice-president in charge of engineering, The Southern New England Telephone Company, New Haven, Conn., has been transferred to the grade of Fellow on the AIEE ". . . for his contributions to conversion of manual telephone systems to dial operation." Mr. Johnson was born in South Norwalk, Conn., on October 26, 1897. He graduated from Pratt Institute in 1919 and joined the Connecticut utility the following year as a field engineer in the traffic department. In 1926, he was promoted to dial traffic engineer, responsible for the traffic design and engineering of all dial central office equipment and switchboards. In this period, he had a large share in the design of an automatic toll switching network, which by 1931 interconnected most of the major toll offices in the territory. He became general traffic engineer in 1930 and plant extension engineer in 1934. In 1943, Mr. Johnson was promoted to chief engineer and in 1953 was elected

E. A. Johnson

Corbett McLean

Chell Frantzen Studios

D. E. Trucksess

a vice-president. In this capacity, he is responsible for the engineering of all company buildings and equipment, heading a force of nearly 300 employees. He was largely responsible for converting the company's 1.1 million telephones to dial operation; this program was completed in 1953. In addition, Mr. Johnson has directed the introduction of direct distance dialing, which is now available to 71% of the company's customers. His Connecticut AIEE activities have included membership on the Executive Committee (1952-54) and chairmanship of the Management Technical Subcommittee (1954-56). He has been active on the national AIEE General Industry Applications Committee (1954-55) and Wire Communications Systems Committee (1954-55). He is a registered professional engineer in the State of Connecticut. Mr. Johnson is a member of the Pratt Institute School of Engineering Advisory Council and in 1956 received Pratt's Alumni Award.

Corbett McLean (AM '34, M '38), supervisor, Engineering Division, Pacific Power & Light Company, Portland, Oreg., has been transferred to the grade of Fellow in the AIEE ". . . for his contributions to development of an extensive power system." Mr. McLean was born in Portland on December 24, 1905. He received his A.B. degree in E.E. from Stanford University in 1927 and his professional E.E. degree from the same University in 1929. He has completed courses in aerial bombardment protection at Oregon State College and plant protection school sponsored by State of Oregon Defense Council. Mr. McLean began his engineering career in 1929 as draftsman and computer with Northwestern Electric Company. He subsequently became engineering estimator, electrical engineer, supervisor, and assistant engineer. From 1938 to 1947, he functioned under the latter title as chief engineer. In 1948, shortly after the merger into Pacific Power & Light Company, he became acting supervisor, then supervisor, Engineering Division, with direct supervision over the Design, Planning and System Engineering, Estimating, and Distribution Sections. Mr. McLean is the author of several technical papers. He is a member of Sigma Xi, Conference Internationale des Grands Reseaux Electriques, and Professional Engineers of Oregon. He has served as chairman of the Electrical Equipment Committee and member of the Executive Committee, Engineering and Operating Section, Northwest Electric Light & Power Association; secretary and treasurer of Portland Electric Light Association; member of the Oregon Technical Council; president of the Electric Club of Oregon; member of the Hydraulic Power Committee of the Edison Electric Institute (EEI), and correspondent on the Air Pollution Control Committee of EEI. He is presently a member of the Radio-Electrical Coordination C-63 Sectional Committee, American Standards Association (ASA), and correspondent advisor on the Subcommittee on Power and Distribution Transformers ASA C-57. Mr. McLean has been listed in "Who's Who in Engineering" since 1941 and is a registered professional engineer in the States of Oregon, Washington, Idaho, and Wyoming. He has served as chairman of the Portland Section of the Institute and was a member of the AIEE Protective Devices Committee (1948-51).

David E. Trucksess (M '40), power development engineer, Bell Telephone Laboratories, Inc., New York, N. Y., has been transferred to the grade of Fellow in the AIEE ". . . for his contributions to power supplies for high frequency communication systems." Mr. Trucksess was born in Philadelphia, Pa., on January 10, 1905. He received a B.S. degree in E.E. from the Pennsylvania State University in 1926. Upon graduation, he joined the Bell Telephone Laboratories and was engaged in the development of ringing machines, tone generators, and small motors for use in the Bell System. He was responsible for the design and development of regulated rectifiers for supplying power for telephone equipment. During World War II, he was the supervisor of a group designing power supplies for military radar, sonar, and radio equipment for Army, Navy, and Signal Corps. After the war, work was resumed on the design of power supplies for telephone equipment with emphasis on supplies for microwave and television equipment. In 1953, he was made a subdepartment head with the title of power development engineer. The department was responsible for rectifier design and a new group of engineers to do long-range planning of power developments. In 1956, he was put in charge of a department with the complete responsibility for the design of power systems to supply power to the specific systems for the switching, transmission, and military departments such as the electronic switching system, microwave systems, Transatlantic and Pacific submarine cables, and sonar systems for the Navy. He is responsible for the design of the power arrangements for the Bell Systems 4,000, 6,000, and 11,000 megacycle nation-wide microwave systems. Mr. Trucksess is a member of the Telephone Pioneers and a senior member of the Institute of Radio Engineers. He is active in the National Society of Professional Engineers, serving as a trustee to the New Jersey Society and past president of the Union County Chapter. He is a registered professional engineer in New Jersey. Mr. Trucksess has served on the following AIEE Committees: Electronics (1948-59); Metallic Rectifiers (1949-58, chairman 1955-57); Electronic Power Converters (1947-52); Science and Electronics Division (1955-59, chairman 1958-59); and Award of Prizes (1956-58).

AIEE PERSONALITIES

C. F. Wagner (AM '20, F '40, Member for Life), consulting engineer for the Apparatus Division, Westinghouse Electric Corporation, and internationally known authority on power transmission and lightning protection, has been awarded the Westinghouse Service Pin in honor of his 40-year career with the company. Dr. Wagner has attained the prolific average of one patent a year since beginning his professional career. In 1951, he received the Edison Medal for ". . . distinguished contributions in the field of power system engineering." Dr. Wagner is a member of Tau Beta Pi and Sigma Xi and a recipient of the Westinghouse Order of Merit. In 1940, he was awarded the honorary degree of doctor of engineering by Illinois Institute of Technology. Dr. Wagner has served on the following Institute Committees: Power Transmission and Distribution (1930-32, 1937-58, chairman 1947-49); Publication (1943-49, chairman 1946-47); Planning and Co-ordination (1945-57); Award

of Institute Prizes (1945-47, 1952-59); Institute Publications (1945-47); Power Division (1947-55); Standards (1947-49); Technical Program (1947-49); and Edison Medal (1953-58).

W. R. G. Baker (AM '19, F '47, Member for Life), vice-president for research, Syracuse University, and president of Syracuse University Research Corporation, has been elected to the board of directors of Gulton Industries, Inc., Metuchen, N. J. Prior to his retirement, he was vice-president of the General Electric Company responsible for all electronic activities. Dr. Baker is a past president of the Electronic Industries Association and continues to serve as director of engineering. He is also a past president and treasurer of the Institute of Radio Engineers. Dr. Baker has served on the following Institute Committees: Award of Institute Prizes (1947-48, 1949-52); Electronics (1945-57, chairman 1945-47); Standards (1945-47); Technical Program (1945-48); Communication and Science Coordinating (chairman 1947-48; and Planning and Co-ordination (1947-50).

T. M. Blakeslee (AM '29, F '48), electrical engineer in charge of operations for the City of Los Angeles Department of Water and Power, spoke during the American Power Dispatchers Association Southwest Area Summer Meeting, held August 2, 1958, in North Hollywood, Calif., on the controversial issue of "Pink Water" or "Disputed Water" of the Hoover and Davis Dam projects. Mr. Blakeslee has served on the following AIEE Committees: Instruments and Measurements (1936-39), Power System Communications (1950-58), and Power Generation (1956-58).

J. H. Oliver (AM '30, M '41), recently retired after 35 years service with the General Electric Company, has been named sales promotion manager in charge of preparation of application information for Aerovent Fan & Equipment, Inc., Lansing, Mich. Mr. Oliver's work with GE involved farm electrification with the company's Apparatus Sales Division. He serves on the Farm Equipment and Structures Research Advisory Committee for the Secretary of Agriculture, and on the Materials Handling Subcommittee of the American Society of Agricultural Engineers. Mr. Oliver is a member of the AIEE Domestic and Commercial Applications Committee.

R. A. Schatzel (AM '28), vice-president of engineering and research director of Rome Cable Corporation, Rome, N. Y., has been granted a United States patent for Roseal, a polyethylene butyl rubber resin used primarily as a sheathing compound on electrical wires and cables. The patent has been assigned to Rome Cable. Mr. Schatzel has served on the AIEE Insulated Conductors Committee (1947-56).

M. J. O'Laughlin (AM '47, M '55), of the Northern Indiana Public Service Co., has been appointed manager of substation sales, Handley-Brown Company, Jackson, Mich., fabricator of the newly developed Alrectic system of standardized aluminum substations. Mr. O'Laughlin has been active in the Chicago Section of the Institute.

J. R. Steen (M '48), division manager of quality control, Semiconductor Division, Sylvania Electric Products, Inc., has been appointed engineering reliability specialist for the Ballistic Missile Early Warning System (BMEWS) Program of Sylvania Electronic Systems, a division of Sylvania Electric Products Inc. Mr. Steen has served on the AIEE Electronics Committee (1951-58).

E. V. Lindseth (AM '45, M '57), assistant director of the Bureau of Reclamation's Regional Office in Denver, Colo., has been named assistant chief designing engineer. Mr. Lindseth is a registered professional engineer in the State of Colorado.

J. C. Paull (AM '52), staff engineer, overhead lines department, Detroit Edison Company, has been appointed assistant superintendent of the company's Detroit Overhead Lines Division.

R. T. Blakely (AM '36, M '43), manager of the Engineering Services Division, Burroughs Research Center, Paoli, Pa., has been appointed corporate staff engineer in the executive engineering office. Mr. Blakely will assist **Dr. Irven Travis** (M '46), vice-president of research and engineering, Burroughs Corporation, in planning the engineering program for the Series G electronic high-speed printing and tabulating machine. His headquarters will be at Control Instrument Company, Brooklyn, N. Y., wholly owned subsidiary of Burroughs Corporation, where the Series G is being produced.

R. L. Haney (AM '43), manager, Allentown, Pa., district of Allis-Chalmers Manufacturing Company Industries Group, has been appointed manager of the Philadelphia district. Mr. Haney is an electrical engineering graduate of Lehigh University.

A. B. Hull, Jr. (AM '55), of the Tampa Electric Company, Tampa, Fla., has been appointed head of the power firm's Distribution Engineering Section.

R. E. King (AM '48), distribution equipment headquarters sales supervisor, Square D Company, Detroit, Mich., has been appointed distribution equipment sales manager. In his new position, Mr. King will be responsible for all distribution sales programs, including the headquarters sales department, field office liaison, general sales procedures, and field engineering training.

F. H. Roby (AM 37, M '41), vice-president and director, Square-D Company, Detroit, Mich., has been appointed an executive vice-president of Federal Pacific Electric Company, Newark, N. J. Currently vice-president and member of the Board of Governors of the National Electrical Manufacturers Association, Mr. Roby is also a member of the American Welding Society, Association of Iron and Steel Engineers, and Engineering Society of Detroit.

M. R. Shaw (AM '40, M '46) supervisor of applications engineering, electronic components sales department, Corning Glass Works, Corning, N. Y., has been appointed supervisor of product engineering. He served on the AIEE Electronics Committee (1949-51).

J. A. Boyd (AM '47, M '54), professor of electrical engineering, The University of Michigan, and associate director of the Engineering Research Institute (now established as the University of Michigan Research Institute), has been appointed director of the Willow Run Laboratories of The University of Michigan. Dr. Boyd is a member of Sigma Xi, Eta Kappa Nu, Tau Beta Pi, and the Institute of Radio Engineers. He has served on the following Institute Committees: Feedback Control Systems (1955-56) and Industrial Control (1955-58).

Harold Lyons (M '47), head of the atomic physics department of Hughes Aircraft Company, Culver City, Calif., has been awarded a Certificate of Merit by The Franklin Institute for ". . . his work in pioneering the development of clocks of very great precision based on the natural periods of vibration of atoms and employing microwave techniques." Dr. Lyons has served on the AIEE Instruments and Measurements Committee (1948-52) and Electronic and High Frequency Instruments Committee (1956-58).

W. S. Edsall (M '19, Member for Life) has retired as president of The Chase-Shawmut Company, a subsidiary of I-T-E Circuit Breaker Company, in Newburyport, Mass. Still a director, Dr. Edsall will continue on with the company in a consulting capacity. Internationally known as an authority on circuit protection, Dr. Edsall joined Chase-Shawmut in 1945 as vice-president and was made president soon after. He has been a member and chairman of many committees of the National Electrical Manufacturers Association. He served on the AIEE Protective Devices Committee (1923-36, 1942-44).

H. H. Gnuse, Jr. (AM '34, M '46), vice-president in charge of operations and a director, Nantahala Power & Light Co. (subsidiary of Aluminum Company of America), has been appointed senior power engineer, Aluminum Company of America, and has transferred to the company's main office in Pittsburgh, Pa.

OBITUARIES

William Barwise Coulthard (AM '28, M '34), professor, department of electrical engineering, University of British Columbia, Point Grey, Vancouver, B. C., Canada, died recently. Prof. Coulthard was born in England in 1893. He received his B.S. degree from Faraday House, London, England, in 1920, after having his studies interrupted by World War I during which he served with the Royal Engineers (telecommunications) in France from 1915 to 1918. Upon completion of his university work, he spent seven years in electrical manufacturing industries in England. From 1927 to 1929 he lectured in electrical engineering at the University of British

Columbia. He published a book entitled "Transients in Electric Circuits" and a number of papers on electrical machines. He served on as a counselor for the AIEE Vancouver Section Student Branch from 1934 to 1951. Prof. Coulthard was a member of the International Electrical Engineers of Great Britain.

Warren J. Dornhoefer (AM '48, M '51), president and secretary of the Warren Manufacturing Company, Littleton, Mass., died recently at the age of 37. Mr. Dornhoefer was born in New York, N.Y., on August 14, 1921. He received an electrical engineering degree from Manhattan College in 1943. After three years service in the U.S. Navy during World War II, he attended Yale University from which he received his master's degree. Mr. Dornhoefer began his career with the Ward Leonard Electric Company, Mount Vernon, N. Y., and from 1948 to 1951, was section head of its Vickers Electric Division in St. Louis, Mo. He became chief engineer of the Regulator Equipment Corporation in 1951, and the following year, he was named president of the corporation in Paterson, N.J. He became president of the Warren Manufacturing Company in 1957. Mr. Dornhoefer was a member of the Institute of Radio Engineers and was treasurer of the New England Chapter of the Young Presidents Organization. He served on the AIEE Magnetic Amplifiers Committee (1951-58, chairman 1954-56) and Science and Electronics Division (1954-56).

Thomas Charles Duncan (M '14, Member for Life), retired, died recently at the age of 81. Mr. Duncan was born October 11, 1878, in Owen Sound, Ont., Canada. Mr. Duncan received his technical education from an International Correspondence School course in electrical engineering, and also attended a school of business administration. During his engineering career he worked for companies in Manitoba; in the State of Washington; in Auckland, New Zealand; and in northern British Columbia. At the time of his retirement in 1948, he was a field engineer in the electrical distribution department of the British Columbia Electric Railway Co., Vancouver, B. C., Canada.

Charles DeVan Fawcett (AM '14, M '20, F '51, Member for Life), emeritus professor, Moore School of Electrical Engineering, University of Pennsylvania, died recently. Prof. Fawcett was born December 31, 1887. He graduated from the University of Colorado with the degree of B.S. in E.E. in 1911. After a brief term as instructor in electrical engineering at Colorado, and a year with the General Electric Co., he joined the electrical engineering staff at the University of Pennsylvania in 1914. He rose to the rank of professor in the University's Moore School of Electrical Engineering, and upon his retirement in 1956 was honored with the title of emeritus professor. At Moore School Prof. Fawcett specialized in the development and teaching of courses in the power field, and in courses in electrical engineering for students from other schools of the University. He was influential in the design and construction of the Moore School differential analyser. Prof. Fawcett was co-author with Charles M. Gay of the widely used textbook "Mechanical and Electrical Equipment for Buildings" (John Wiley and Sons, 1937). Prof. Fawcett was also well known as a consulting engineer for several companies including Albert C. Wood Associates, Emergency Fleet Corporation, Radio Corporation of America, and Philadelphia Electric Company. Prof. Fawcett was a member of the Illuminating Engineering Society, the American Society for Engineering Education, the International Commission on Illumination, and the Engineers Club of Philadelphia. He was a registered professional engineer in Pennsylvania. He was also a past chairman of the Philadelphia Section of AIEE.

William W. Omin (AM '42, M '47), assistant secretary and purchasing agent, W. V. Pangeborne & Co., Inc., died recently at Milford, Pa. Mr. Omin was born in Philadelphia, Pa. After serving several years as designing engineer for the Fourth Naval District and the Philadelphia School District, he was manager of the Ace Electric Service Company from 1949-51, and in April 1951 joined W. V. Pangeborne & Co. as purchasing agent. He was a graduate of the 1936 class of Drexel Institute of Technology Evening School. Mr. Omin was a member of the Engineers' Club of Philadelphia, the Illuminating Engineering Society, the National Association of Purchasing Agents, and the Society of American Military Engineers.

Frank Foster Shipley (M '43), director of switching engineering, Bell Telephone Laboratories, New York, N. Y., died recently. He was 60 years old. Born in Red Ash, Ky., Mr. Shipley attended Indiana State Teachers College. He received the B.S. degree in E.E. from Purdue University in 1925. After working for the American Telephone and Telegraph Company, Mr. Shipley joined the Bell Laboratories in 1934. As director of switching engineering, Mr. Shipley directed the planning and co-ordination of the company's developments in its dial and manual telephone-switching systems. He was the author of many technical articles in his field and held several patents on telephone switching systems. Mr. Shipley was a member of Tau Beta Pi and Eta Kappa Nu.

Frank P. Vaughan (M '15, Member for Life), president, Vaughan Electric Company, Ltd., St. John, N. B., Canada, died recently. Mr. Vaughan was born on June 3, 1874, in Liverpool, England. Educated in England, Mr. Vaughan began his career with the New Westminster and Burrard Inlet Telephone Company in Vancouver. He was also employed by the Yarmouth Street Railway Company, Yarmouth, N. S.; the Northern Electric Works, St. John; and two companies in Boston, Mass. From 1900 to 1902, he was employed by the General Electric Company in Schenectady, N. Y. In 1902, he returned to St. John and established a private practice incorporated in 1906 as the Vaughan Electric Company, Ltd. One of the first licenses granted in Canada for a wireless telegraphy experimental station was received by Mr. Vaughan for his station in St. John. In 1923, he designed, built, and put into operation the first radio broadcasting station in New Brunswick—Station 9-B1. In 1922, he was awarded an honorary M.S. degree from New Brunswick University. Mr. Vaughan was a member of the code committee for New Brunswick of the Engineering Standards Association, Ottawa; a member of the American Association for the Advancement of Science; an associate member of the Institute of Radio Engineers; and a member of the Association of Professional Engineers of New Brunswick.

Edwin R. Walton (AM '18, Member for Life), retired, died recently. Mr. Walton was born in Lincoln, Nebr., on January 25, 1881. He studied electrical engineering at the University of Nebraska. In 1905, he joined the General Electric Company in the testing department, Schenectady, N. Y. During his career, he was employed by Allis-Chalmers Manufacturing Company, Kenosha, Wis., Gas & Electric Company, and other firms. He retired in 1951 from the Illinois Power Company, Decatur, Ill., after many years in the service of that company and its predecessor, the Illinois Power and Light Company.

Walter Farrington Wells (AM '99, M '08, F '12, Member for Life), retired, died recently at the age of 88. In 1892 Mr. Wells graduated from Rutgers from which he received an honorary electrical engineering degree in 1915. After a long career, he retired in 1935 from the Brooklyn Edison Company where he had served as first vice-president, general manager, and a director. Brooklyn Edison and the Queens Electric Light & Power Co. were merged into the Consolidated Edison Company in 1945. Mr. Wells was a past president of the Association of Edison Illuminating Companies and of the National Electric Light Association. He was a charter member of the Brooklyn Chamber of Commerce, a member of the Chamber of Commerce of New York State, a member of the Edison Pioneers, and of the Society of Colonial Wars. Mr. Wells served on the AIEE Power Stations Committee (1917-19).

Albert Francis Zito (AM '45), owner, Arrow Electric Co., Denver, Colo., died recently. He was 49 years old. Mr. Zito was born September 25 1908. He was an electrical engineering graduate of the University of Colorado. Previous to World War II, Mr. Zito worked for the Public Service Co. of Colorado. During the war, he worked with the electrical contracting firm of Evans, Collier, and Lord on the Denver Ordnance Plant and later as chief of electrical engineering for the Sunflower Ordnance Plant. In 1946, Mr. Zito formed his own electrical contracting firm, the Arrow Electric Co.

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AIEE Section and Student Branch Meetings 1957-58

Table I. Section Membership, August 1958; Section Meetings During Year Ending April 30, 1958

Section	AIEE Members August 1958	Number of Meetings	Total Number of Meetings
Akron	242	8	
Group: Power Technical Discussion		4	12
Alabama	355	9	
Group: Communications		6	
Subsection: Montgomery		9	24
Arizona	322	9	
Groups: Computer Division		4	
Electronics and Communication Division		8	
Industrial Division		3	
Mining Division		1	
Power Division		8	
Technical Session		3	36
Arkansas	155	8	
Groups: Communication		1	
Power		1	
Technical		1	
Subsection: Northwest Arkansas		5	16
Arrowhead	75	9	
Groups: Industrial Discussion		4	
Utility Discussion		4	17
Baton Rouge	94	10	10
Beaumont	124	13	
Subsection: Lake Charles		6	
Joint Meeting: Section and Lake Charles Subsection		1	20
Boston	1223	8	
Group: Technical		23	31
Canton	112	10	
Groups: Communication and Electronic Discussion		3	
Power Discussion		4	
Substation and Distribution Discussion		3	20
Central Illinois	230	9	
Group: Technical		1	10
Central Indiana	402	9	9
Chicago	2234	9	
Groups: Basic Sciences		3	
Communications		4	
Electronics		4	
Industrial		5	
Power		4	
Young Engineers		1	
Joint Meetings: Power and Communications		1	
Basic Sciences, Industrial, and Electronics		1	32
Cincinnati	412	10	10
Cleveland	1161	9	
Groups: Analog Computer		4	
Basic Sciences		4	
Digital Computer		3	
Electrical Construction		1	
Electrical Installations		3	
Electronics - Communication-Instrumentation		5	
Management		4	
Motor and Control		6	
Power Generation and Distribution		5	
Joint Meeting: Digital Computer, Analog Computer		1	45
Columbus	295	9	
Group: Management		16	
Subsections: Chillicothe		6	
Zanesville		13	44
Connecticut	926	8	
Groups: Communications		3	
Electric Power Generation, Transmission, and Distribution		5	
Electrical Controls and Measurements		3	
Industrial Electronics		2	
Industrial Power Applications		3	
Management		3	
Subsection: New London		4	31
Corpus Christi	120	14	
Group: Technical		1	
Subsection: Victoria-Port Lavaca		8	23
Dayton	351	4	
Groups: Computers		1	
Industrial Control		2	
Instrumentation		2	
Management		1	
Nucleonics		3	
Power Discussion		2	
Rotating Machinery		4	
Joint Meeting: Instrumentation, Industrial Control		1	20
Delaware Bay	191	10	
Group: Discussion		2	12
Denver	535	11	
Groups: Aeronautical Technical Communications and Electronics		4	
Electrical Equipment Technical		5	
Power and Equipment Technical		2	
Power Systems Technical		3	
Subsection: Black Hills		6	34
East Tennessee	485	32	
Subsections: Huntsville		3	
Muscle Shoals		12	
Tullahoma		9	
Upper East Tennessee		3	59
El Paso	136	14	14
Erie	239	13	
Groups: Computing Devices		6	
Management		2	21
Fort Wayne	213	9	
Group: Rotating Machinery Technical Discussion		2	
Subsection: Marion		4	15
Georgia	404	12	
Subsection: Rome		5	17
Hamilton	230	10	
Group: Technical		6	
Subsections: Guelph		4	
London		1	
Joint Meetings: Section, Guelph and London Subsections		1	
Section and Guelph Subsection		1	23
Hawaii	110	12	
Group: Technical		6	18
Houston	448	9	
Groups: Industrial Applications Technical		6	
Power Technical		1	
Technical		2	
Subsection: Freeport		8	
Joint Meetings: Section, Petroleum Technical, and Industrial Applications		1	
Industrial Applications and Petroleum Technical		1	28
Idaho	90	7	
Subsection: Southern Idaho		10	17
Illinois Valley	86	12	
Group: Technical		9	21
Iowa	188	11	
Groups: Communications and Electronics		1	
Electric Power Technical		1	
Technical		7	
Subsections: Cedar Valley		1	
Northwest Iowa		7	28
Iowa-Illinois	163	4	
Groups: Communications Technical		1	
Industrial Technical		1	
Power Technical		1	7
Ithaca	356	14	
Group: Technical Discussion		5	
Subsection: Binghamton Area		6	
Joint Meeting: Section and Binghamton Area Subsection		1	26
Jacksonville	149	10	10
Johnstown	77	12	
Groups: Electronics and Communications		2	
Industrial Applications Technical		5	19
Kansas City	425	12	
Groups: Communications Technical		3	
Computers Technical		4	
Industrial Power Technical		4	
Lighting Technical		1	
Petroleum Technical		3	
Power Generation, Transmission, and Distribution		4	
Power Technical		1	32
Lehigh Valley	461	10	
Group: Technical Discussion		35	45
Lima	121	5	
Groups: Aeronautics Discussion		4	
Motor and Control Discussion		4	13
Los Angeles	2657	8	
Groups: Aircraft Division		6	
Basic Sciences Division		4	
Communications Division		7	
Electronics Division		5	
Industry and Construction Division		6	
Magnetics Division		5	
Management Division		3	
Power Division		7	
Young Engineers Division		6	
Subsections: Boulder City		7	
Riverside-San Bernardino		8	
Joint Meetings: Basic Sciences and Young Engineers Div.		1	
Electronics and Young Engineers Division		1	
Basic Sciences and Electronics Division		1	75
Louisville	225	12	
Group: Technical Discussion		13	
Subsections: Lexington		8	
Paducah		4	37
Lynn	315	15	
Groups: Illumination Technical		2	
Industrial Application Technical		1	
Instrumentation Technical		2	
Power Technical		2	
Science and Electronics Technical		2	
Subsection: Merrimack Valley		7	31
Madison	105	8	
Group: Technical Discussion		1	9
Maine	315	6	
Groups: Augusta Power Technical		9	
Northern Maine Technical		1	16
Mansfield	124	8	8
Maryland	939	9	
Groups: Aircraft Technical		5	
Automatic Control Technical		5	
Communication Technical		5	
Industrial Electronics		3	
Management Technical		4	
Power Technical		5	
Subsection: Eastern Shore		8	42
Memphis	157	12	
Groups: Industrial Controls Technical		3	

Section	AIEE Members August 1958	Number of Meetings	Total Number of Meetings
Transmission and Distribution Technical	4		
Subsection: Jackson	2		21
Mexico	173	12	
Group: Technical	2		
Subsection: Monterrey			14
Miami	270	12	
Groups: Grounding Technical	9		
Relay Technical Discussion	3		24
Michigan	1123	8	
Groups: Communications Technical	3		
Industry	3		
Management	6		
Power Technical	8		
Science and Electronics	3		31
Milwaukee	988	7	
Groups: Basic Science Discussion	4		
Electrical Machinery Discussion	3		
Electronics Discussion	3		
Power Application and Control Discussion	2		
Transmission and Distribution	2		
Subsection: Fox River Valley	6		
Joint Meeting: Basic Sciences and Electrical Machinery Discussion	1		28
Minnesota	472	14	
Subsection: Red River Valley	9		23
Mississippi	92	9	
Groups: Communications Technical	4		
Power Technical	5		
Technical Discussion	2		20
Mobile-Pensacola	145	11	11
Montana	123	8	
Group: Technical	11		
Subsections: Billings	18		
Helena	8		
Joint Meeting: Power System Technical Group and Billings Subsection	1		46
Montreal	550	10	
Subsection: Quebec	9		19
Nashville	112	8	8
Nebraska	227	11	
Group. Technical	22		33
New Hampshire	167	10	
Group: Technical	3		13
New Orleans	273	9	
Group: Technical	5		14
New York	6190	1	
Groups: Basic Sciences	4		
Communications	10		
Illumination	4		
Power and Industrial	16		
Transportation	8		
Subsections: Hudson Valley Division	9		
New Jersey Division	10		
Joint Meetings: Basic Sciences and Communications	3		65
Niagara Frontier	386	9	
Group: Technical	8		17
Niagara International	149	11	11
North Carolina	498	2	
Subsections: Charlotte	11		
Eastern North Carolina	9		
Western North Carolina	5		
Mid-State			27
North Texas	717	10	
Groups: Communications Division	4		
Industry Division	6		
Technical	15		
Subsections: Central Texas	3		
Fort Worth	6		
West Central Texas	9		
Joint Meetings: Section and Fort Worth Subsection	1		
Fort Worth Subsection and Aircraft Technical	1		55
Northeastern Michigan	134	12	12
Northeastern Wisconsin	99	2	2
Northern New Mexico	211	6	
Subsection: Los Alamos-Santa Fe	7		
Joint Meeting: Section and Los Alamos-Santa Fe Subsection	1		14
Oak Ridge	71	11	11
Ohio Valley	83	8	
Group: Transformer Technical	2		
Subsection: Scioto Valley	11		21
Oklahoma City	212	9	
Groups: Communication-Electronics Discussion	4		
Discussion	5		
Industrial Practices Discussion	4		
Management Discussion	5		
Power Discussion	5		32
Ottawa	110	12	
Group: Technical	3		15
Panhandle Plains	152	10	
Groups: Technical	2		
Technical Session	3		15
Philadelphia	2099	7	
Groups: Aircraft Electrical Discussion	3		
Communications Technical	4		
Management Technical	3		
Power and Applications Technical	2		
Power Systems Discussion	2		
Science and Electronics, Instrumentation Division	13		
Subsection: Atlantic City Division	8		
Joint Meetings: Section and Communications	1		
Power-Applications Technical and Aircraft Electrical	1		
Power-Applications Technical and Industrial Practices	1		45
Pittsburgh	1546	30	
Groups: Communications Technical	1		
Instrumentation Technical	1		
Technical Discussion	1		
Subsection: Centre County	7		40
Pittsfield	411	11	
Groups: Electronics Technical	2		
Industry Technical Discussion	1		
Instrumentation Technical	1		
Power Technical	3		
Science and Electronics Technical	1		
Subsection: Vermont	8		27
Portland	526	23	
Groups: Communications-Electronics Technical	3		
General Applications and Safety Technical	1		
Industry Technical	5		
Power Technical	14		
Portland Area Technical	2		
Research and Basic Sciences Technical	4		
Subsections: Eugene	18		
Medford	7		77
Providence	254	8	
Groups: Cable Technical	2		
Electronics Technical	5		
Power Technical	2		
Joint Meeting: Section and Electronics Technical	1		18
Richland	107	7	
Groups: Computing Devices	2		
Industrial Power Systems	3		
Instrumentation-Control Technical	5		
Transmission-Distribution	2		19
Ridgway	63	9	9
Rochester	320	17	
Groups: Communications-Science and Electronics	1		
Industrial Discussion	1		
Power Technical	2		21
Rock River Valley	144	11	11
Sacramento	184	11	
Groups: Construction and Design Technical	4		
Electrical Applications Technical	4		
Electronics Technical	9		
Transmission and Distribution Technical	7		35
St. Louis	791	13	
Groups: Industrial Apparatus Discussion	6		
Power Practices Discussion	8		
Technical Group on Education	1		
Vocational Guidance Technical	4		
Subsection: Eastern	6		
Joint Meeting: Industrial Apparatus Discussion and Power Practices	1		39
St. Maurice Valley	54	8	8
San Diego	281	10	
Groups: Aircraft and Missile Technical	5		
Aviation and Missile Technical	5		
Electronics Technical	6		
Industrial Technical	6		
Management Development Technical	4		
Utility Technical	8		
Joint Meeting: Electronics Technical and Aircraft and Missile	1		45
San Francisco	1876	15	
Groups: Communication Division	8		
General Application Division	4		
Industry Division	5		
Instrumentation Div.	4		
Power Division	6		
Science and Electronics Division	8		
Subsections: Fresno	8		
Reno	9		
San Jose	9		
Shasta	9		83
Savannah	62	9	9
Schenectady	929	18	
Subsection: Adirondack	2		20
Seattle	826	9	
Groups: Aircraft Technical	7		
Basic Sciences	5		
Feedback Control	5		
Industrial Technical	2		
Management Technical	1		
Power Technical	4		
Subsection: Tacoma	4		
Joint Meeting: Section and Basic Sciences Technical Group	1		86
Sharon	259	10	
Group: Technical	2		12
Shreveport	172	10	
Groups: Communications and Electronics Technical	1		
Distribution Technical	1		
Management Technical	3		
Relay and Control Technical	3		
Transmission and Distribution Technical	5		
Subsection: Monroe	9		
Joint Meeting: Section and Monroe Subsection	1		33
South Bend	129	11	

Section	AIEE Members August 1958	Number of Meetings	Total Number of Meetings
Groups: Domestic and Commercial Applications			
Technical		5	
Technical		1	17
South Carolina	229	3	
Subsections: Central Savannah River Area		8	
Charleston		8	
Columbia		10	
Piedmont		10	39
South Texas	129	13	13
Spokane	203	12	
Groups: Bridgeport Technical		1	
Electronics Technical		3	
Industrial Application		8	
Management Technical		5	
Nuclear Power Technical		4	
Transmission and Distribution Technical		5	
Subsection: Wenatchee		11	
Joint Meeting: Wenatchee Subsection and Bridgeport Technical		1	50
Springfield	153	8	
Group: Technical		4	12
Susquehanna	137	8	8
Syracuse	480	12	
Group: Technical		1	
Subsection: St. Lawrence International		3	16
Tampa	374	6	
Group: Phosphate Mining Industries Technical		1	7
Toledo	184	19	
Group: Power Technical		2	21
Toronto	770	17	
Groups: Communications Discussion		6	34
Tulsa	222	11	
Groups: Technical		14	
Utilities Technical		1	26
Utah	116	8	
Group: Industry and Mining		1	9
Vancouver	288	10	
Group: Technical Discussion		15	25
Victoria	89	12	
Groups: Industrial Equipment and Applications		4	
Power System Engineering Discussion		4	
Protective Devices Discussion		3	
Transmission and Distribution		2	2
Virginia	343	2	
Subsections: Blue Ridge		6	
Hampton Roads		9	
Richmond		7	24
Virginia Mountain	252	7	7
Washington	1026	11	
Group: Management Technical		1	12
West Michigan	129	8	8
West Virginia	132	9	
Group: Power and Distribution Technical		1	
Subsection: Charleston		1	11
Wichita	122	12	
Group: Technical		8	20
Worcester	127	7	
Groups: Insulated Conductors Technical		2	
Transmission and Distribution Technical		1	10
	49,510		2,670

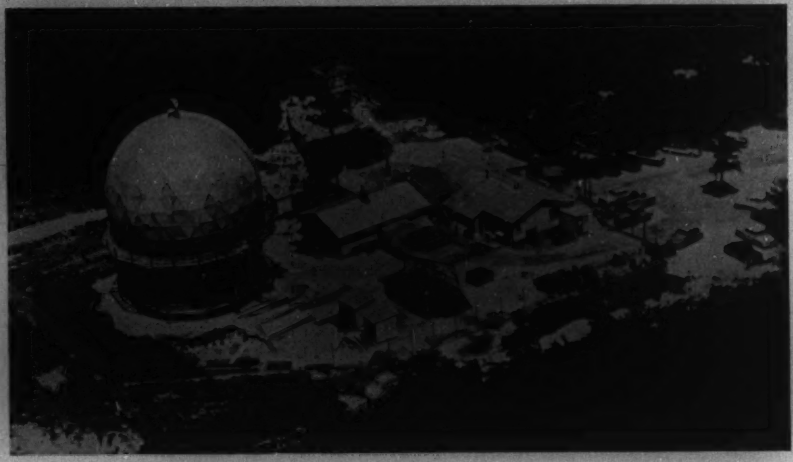
Total Sections, 112
Total Technical Groups, 235
Total Subsections, 68

Table II. Branch Meetings Held During Year Ending April 30, 1958

Branches	Number of Meetings
*Akron, University of	6
Alabama Polytechnic Institute	13
*Alabama, University of	13
Alaska, University of	11
*Alberta, University of	10
*Arizona, University of	14
*Arkansas, University of	8
†Bradford Durfee College of Technology	5
*British Columbia, University of	25
*Brooklyn, Polytechnic Institute of	
Day Division	14
Evening Division	9
*Brown University	3
*Bucknell University	3
†Buffalo, University of	5
*California Institute of Technology	2
†California State Polytechnic	10
*California, University of	21
*Carnegie Institute of Technology	9
Case Institute of Technology	11
Catholic University of America	4
†Christian Brothers College	8
*Cincinnati, University of	8
*Clarkson College of Technology	
*Clemson A & M College	8
*Colorado State University	9
*Colorado, University of	7
*Columbia University	4
*Connecticut, University of	6
*Cooper Union	2
*Cornell University	4
*Dayton, University of	25
*Delaware, University of	6
*Denver, University of	19
*Detroit, University of	8
*Drexel Institute of Technology	7
Duke University	6
Fenn College	7
*Florida, University of	10
†Gannon College	6
*George Washington University	3
Georgia Institute of Technology	12
†Houston, University of	10
*Howard University	14
Idaho, University of	11
Illinois Institute of Technology	19
*Illinois, University of	7
Chicago Branch of Univ. of Ill.	
*Iowa State College	7
Iowa, University of	24
*Johns Hopkins University	16
Kansas State College	12
*Kansas, University of	6
Kentucky, University of	7
*Lafayette College	7
†Lamar State College of Technology	6
Laval University	4
*Lehigh University	5
*Louisiana Polytechnic Institute	10
*Louisiana State University	12
*Louisville, University of	7
*Maine, University of	2
*Manhattan College	6
*Marquette University	8
*Maryland, University of	5
*Massachusetts Institute of Technology	2
*Massachusetts, University of	6
†Merrimack College	
†Miami, University of	7
*Michigan College of Mining and Technology	9
*Michigan State University	11
*Michigan, University of	14
Milwaukee School of Engineering	10
*Minnesota, University of	7
Mississippi State College	9
*Missouri School of Mines and Metallurgy	8
*Missouri, University of	9
*Montana State College	11
*Nebraska, University of	8
*Nevada, University of	7
Newark College of Engineering	4
†New Bedford Institute of Technology	11
*New Hampshire, University of	8
*New Mexico College of A & M Arts	8
*New Mexico, University of	3
*New York, College of the City of	19
*New York University	
Day Division	17
Evening Division	5
*North Carolina State College	11
*North Dakota State College	9
*North Dakota, University of	10
*Northeastern University	16
*Northwestern University	28
*Norwich University	7
*Notre Dame, University of	9
Ohio Northern University	5
*Ohio State University	11
*Ohio University	7
*Oklahoma State University	8
*Oklahoma, University of	8
Oregon State College	11
*Pennsylvania State University	14
*Pennsylvania, University of	13
Pittsburgh, University of	22
*Pratt Institute	10
*Princeton University	4
Puerto Rico, University of	2
*Purdue University	6
*Rensselaer Polytechnic Institute	7
*Rhode Island, University of	12
*Rice Institute	8
*Rose Polytechnic Institute	9
*Rutgers University	16
Saint Louis University	5
*Santa Clara, University of	12
†Seattle University	8
*South Carolina, University of	6
*South Dakota State College	10
South Dakota School of Mines and Tech.	5
*Southern California, University of	13
*Southern Methodist University	7
*Stanford University	6
*Stevens Institute of Technology	4
*Swarthmore College	4
*Syracuse University	3
†Tennessee Polytechnic Institute	12
Tennessee, University of	8
*Texas, A & M College of	13
†Texas College of Arts and Industries	9
*Texas Technological College	12
*Texas, University of	8
Texas Western College	6
*Toledo, University of	9
*Toronto, University of	5
*Tufts College	9
*Tulane University	7
*Union College	5
United States Naval Academy	1
United States Naval Post-Graduate School	1
*Utah, University of	11
Vanderbilt University	9
*Vermont, University of	6
*Villanova University	14
Virginia Military Institute	15
*Virginia Polytechnic Institute	8
*Virginia, University of	8
*Washington, State College of	10
*Washington University	9
*Washington, University of	14
*Wayne University	8
*West Virginia University	4
†West Virginia Inst. of Technology	8
†Wichita, University of	6
*Wisconsin, University of	6
*Worcester Polytechnic Institute	6
*Wyoming, University of	13
*Yale University	1
Youngstown University	11
	1,380

Total Branches 154
*Joint AIEE-IRE Branches 110
†Affiliate Branches 15

OF CURRENT INTEREST



AN/FST-2 site where radar and data-processing equipment are housed in the dome and space below. Maintenance and operating crews are quartered nearby.

Headquarters for SAGE

New York Air Defense Sector

FAR OUT on the Atlantic Continental Shelf stand three-legged depots containing computation representing the latest in insurance against surprise air attack. There are some 20 units in the New England and mid-Atlantic states area ever on the alert for unidentified flying objects.

Semi-Automatic Ground Environment System

The SAGE (semi-automatic ground environment) System is a vast, interconnected network of air defense Direction Centers which receive information from many sources, process the information rapidly on high-speed digital computers, and generate battle orders to jet interceptors and other weapons in the air defense system.

This system makes the air defense of the United States almost automatic in the handling of information and directing of weapons. It is a major advance which utilizes machines for high-speed computing, but does not obsolete man, who must make the ultimate decisions and fly the aircraft.

Positions and tracks (routes that aircraft take) are fed to SAGE by heavy surveillance radars within the United States. Height-finding radars give information about aircraft altitude, and small "gap-filler" radars plug the holes between the large radars.

Three radar networks to the north extend our warning time. Information from these is also fed into the SAGE units. The Pine Tree Line overlaps into Canada; the mid-Canada Line stretches from British Columbia to Newfoundland, and the DEW (distant early warning) Line extends across the top of Alaska and Canada.

Beyond the continental limits, our warning is extended skyward and seaward by the constantly patrolling AEW (airborne early warning) aircraft, which are actual flying radar stations.

Extending the radar defense further from our shores, SAGE heavy radar units are mounted on "Texas Towers"—huge steel platforms located more than 100 miles at sea. Other installations of the giant radars are also strategically land-based throughout the United States.

Civilian and military flight plans are relayed to SAGE by the CAA (Civil Aeronautics Administration) and military flight service centers. Weather conditions are received from the Air Weather Service while "aircraft flashes" from the GOC (ground observer corps) complete the many sources of information for SAGE. Information received is processed, flight plans compared to radar readings, and air tracks numbered.

Capable of detecting approaching aircraft while they are still hundreds of miles away, the heavy radar units generate so much energy that a liquid cooling system is required to prevent the main transmitting tube, or power amplifier, from melting. The radar system emits pulsed bursts of electronic energy that are focused by a 40-foot parabolic antenna rotated constantly by a 20-hp motor. The antenna is housed inside a rubberized nylon bubble or radome. The radome, 50 feet in diameter, weighs 2,300 pounds, but is kept inflated by less than ½ pound per square inch of air pressure supplied by blower motors. The long-range systems, which must operate constantly, are designed as dual-channel systems having one channel in operation and another on stand-by at all times.

The SAGE System can link a dozen radars automatically together to give an informative and comprehensive picture of the air situation over a large area while transmitting information from Sector to Sector easily. With SAGE it is now possible to direct many more weapons than before.

Lincoln Lab Recommendations

Following the recommendations of a group appointed by the U.S. Air Force (AF) to study the problems of air defense and following a demonstration, by the Massachusetts Institute of Technology (MIT) Whirlwind I computer, of the advantages of automatic data processing in an air defense system, Lincoln Laboratory was established.

Perhaps the most basic, original concept of the new system for air defense, as recommended by ADSEC (air defense system engineering committee), was the automatic transmission of radar data and utilization of a centralized electronic computer system to furnish the improved tracking and weapon handling capabilities required to cope with mass air raids by an enemy.

Early in 1953, the conclusions and recommendations of the Laboratory were summarized and presented to the AF in the form of a proposal. In April of the same year, the AF accepted the proposal and authorized the development and production of SAGE.

The Air Defense Command (ADC), in co-operation with Lincoln Lab, compiled and prepared the Operational Plan for Air Defense, on which the design and integra-

tion of SAGE into the over-all air defense system would be based.

The air defense computer needed would profit from the most recent advances in the computer art, including the use of ferrite cores for computer memories, thereby increasing speed, flexibility, and reliability. Similarly, the Burroughs Corporation Research Center accepted an assignment for further development on special equipment for the automatic processing and transmitting of radar data to the computer.

The Western Electric Company, the Bell Telephone Laboratory, and other units of the Bell System became associated with SAGE development in the continental United States.

The AN/FST-2 System

Operated on a constant 24-hour day, 7-day week basis, *AN/FST-2* units have built up impressive records of operational reliability under actual field conditions.

All circuits in the system are designed for the worst possible conditions; circuits are packaged as plug-in units for quick, easy replacement and maintenance. Too, the entire system is duplexed with rapid-transfer facilities for switching from one unit to another.

HIGH-POWER FPS-6 RADAR, used in combination with search radar, will supply several SAGE Sectors with long-range accurate height information on approaching air targets. Antenna reflector shown inside radome is 30 feet high and 7½ feet wide.

The *AN/FST-2* consists of four groups, as follows:

1. The Fine Grain Data Group (a five-step function) accepts raw data from all search radars now in use, detects targets in the presence of noise and clutter, determines range and azimuth, stores target information, and processes data for the digital data telephone service equipment which transmits it to SAGE Directional Centers.

2. The Semi-Automatic Height Finder Group accepts request messages from the Direction Center for height and other specific target information, processes messages to provide bearing information to the height-finder radar antennas and visual information to the operators, and prepares the operator's decision for transmission to the Direction Center.

3. The Power Supply Group minimizes effects of power line transients with a separate motor–alternator which supplies a-c power to all d-c rectifier power supplies. Separate d-c power supply is provided to power and control the magazine drum. Variable d-c voltage supplied can be utilized for marginal checking, offering means of conducting preventive maintenance to reduce downtime.

4. The Switchover Group equipment allows rapid switching of telephone line output and power supplies to either unit of the duplex.

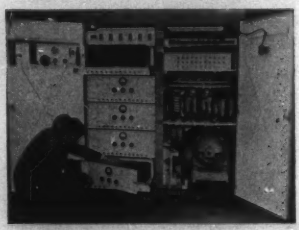
The *AN/FST-2* is designed to operate with all surveillance radar sets including the SAGE nodding-beam type height-finding radar.

The data-processing system is directly compatible with several display devices including the RAPPI (random access plan position indicator), A-scopes, B-scopes, range height indicators, and video mappers.

The *AN/FST-2* defines the target to within a single small block of range, although range resolution is limited to radar capabilities. Standard deviation of range data is figured to a minimum of error. And, all data can be transmitted by the unit in a single second. Through use of a message label, the *AN/FST-2* can transmit to the Direction Center not only target co-ordinates, but also auxiliary data such as target identification, size, spacing, cluster, and test patterns. Other data can be included if desired.

Installation and Servicing

Installation and maintenance teams of Burroughs' Military Field Service Division (MFSD) use past experience in training technical personnel, producing technical operation manuals, logistic support, and field operations.



POWER SUPPLY SYSTEM for AN/FSQ-7 computers is seen in front view showing control panels, motor-alternator sets, static exciter, reactor subassemblies, and 1,440-cycle distribution panel.

Flight support for testing and experimentation was provided by the Cambridge Research Center of the Air Research and Development Command (ARDC), by the Strategic Air Command (SAC), and by the Naval Air Development Unit at South Weymouth, Mass. A complement of AF personnel was activated to operate the experiment sector. When completed, the Experimental SAGE Sector (ESS) was, in all essential aspects, a prototype ground environment, capable of executing all the functions required for air defense. It also functions in the research and development of new equipment and techniques for air defense.

The IBM SAGE Computer is officially described as the *AN/FSQ-7* (Army–Navy fixed special equipment).

As information is processed by this real-time computer (one that deals with events as rapidly as they occur), operating at speeds faster than data can be received, the computer can project forward in time the future course of each aircraft's flight path—providing for immediate identification of hostile planes and determining the most effective defense action to be taken. Command decisions are then made by the AF team, with the computer maintaining electronic control of the intercepting aircraft's or missile's flight path to make the "kill" of the enemy aircraft.

The McGuire computer, shipped in June 1956, is the first production model and, since installation, has been subjected to 2 years of rigid tests and program development.

This computer incorporates the most advanced electronic components. One such component is the high-speed magnetic core memory. The computer's memory has a maximum capacity for words and numbers up to 32 digits per word for both instructions and data. This memory works in conjunction with a dual arithmetic element, each section of which can handle words up to 16 digits and enables the computer to make simultaneous calculations.

For example, given the direct-line distance from a radar to an aircraft and the relation of this line to true north in the form of an angle, the computer can pinpoint the aircraft's actual position. The computer, with electric power requirements equivalent to a town of 15,000 persons, makes considerable use of such new developments as printed wiring and miniaturized components.

Three areas of a continuing program of improvement and upgrading concern components, circuits, and system marginal checking. Automatic self-checking circuits were created and built into the computer to assist in predicting, isolating, and subjecting failures to immediate correction without stopping the computer's operation.

Major subcontractors on the SAGE effort

INTERCEPTOR is "scrambled" against a "HUKP" by 1st Lt. Theodore Cannon (background), weapons director and his assistant S/Sgt. E. E. Flannagan, weapons technician. One look at these controls, and it can be seen that it is more than a one-man job.

with IBM were: Hazeltine Electronics Division of the Hazeltine Corp.; Bendix-York and Bendix Radio Divisions of the Bendix Aviation Corp.; General Electric Co.; Westinghouse Electric Corp.; Fairchild Camera and Instrument Corp.; Power Equipment Co.; Daystrom Instrument Division of Daystrom Inc.; Acme Electric Corp.; Stromberg-Carlson Division of General Dynamics Corp.; Hughes Products Division of Hughes Aircraft Corp.; and Crosley Division of Avco Manufacturing Corp.

Air Warning Net

At the interconnected regional direction centers—one for each air defense sector—the largest electronic computers in the world, each occupying an area of about two acres, monitor the positions of all planes and defense weapons. These regional centers are linked in turn to a national command center.

At these locations, air surveillance data, by means of additional electronic computers, is processed, evaluated, and developed into "Sector level" air situations from which threat evaluation, weapons assignment, and appropriate weapons orders are generated.

Combat Centers are the third step where, after proper evaluation, weapons resources can be monitored and directed. The fourth and last step is Communications, whereby various units are interconnected.

Such complex factors as increased air traffic, dispersed defense bases, and the probability of widely separated, simultaneous, high-density attacks constitute a staggering problem which has been solved by automizing the means of detection, identification, tracking, and interception through SAGE, thus freeing human capability to control and direct the final strategic decisions.

The long-range radar scans the air space in "sweeps" that cover hundreds of square miles and reach extreme altitudes. Although "sweeps" from two long-range radar sites overlap at high altitudes, the curvature of the earth leaves a gap of unscanned air space midway between the long-range sites. In order to plug these holes in the air screen, medium-power gap-filler radar sets were devised to operate automatically, transmitting information via telephone lines to the prime stations. A special television converter at the prime station receives the gap-filler radar information and displays it in correct orientation with the prime site display. Data from both gap-filler and prime radar systems are relayed to SAGE direction centers via telephone line or, in the case of the Texas Tower sites, via microwave radio transmission.

NYADS

A revolutionary concept in air defense became a reality in the New York area when the SAGE System was declared officially operational. The New York Air Defense Sector (NYADS) is one of several planned to span the nation.

Western Electric Company (WE), the manufacturing unit of the Bell System, was assigned the responsibility for engineering management of SAGE. To exercise this responsibility, WE set up ADES (air defense engineering services) Organization under its Defense Projects Division to:

1. Design and construct Direction Center and Combat Center buildings.
2. Co-ordinate all installation and test activities, and monitor to assure that schedules are met.
3. Schedule and budget all components of the system.
4. Develop basic communications plans.

TEXAS TOWER houses data-processing equipment to warn of approaching flying objects from the east is located on the continental shelf out in the Atlantic Ocean.

5. Engineer–co-ordinate changes to the system.
6. Test the Direction Centers and Combat Centers and all associated SAGE System equipment.

The communications industry played a major role by providing communications channels for interconnecting the various SAGE installations. In territory served by the Bell System, these facilities were provided by the Bell telephone companies; elsewhere by independents. The Long Lines department of American Telephone & Telegraph Company provided long-haul interstate channels to tie the SAGE System together and, in addition, co-ordinated the ordering of communications channels within the Bell Telephone family.

A built-in "intelligence" device within the radar equipment separates fixed targets, such as buildings or mountains, from moving targets such as aircraft. Automatic measuring devices then determine bearing and distance to the target. Time required to detect an aircraft at a distance of about 100 miles, for example, is about 1/1000 second.

An 11,471-Tube Set

The input system, which translates incoming information into computer language, requires 11,471 vacuum tubes and more than 30 miles of wiring. It includes electronic equipment that receives long-range radar signals via telephone lines or microwave relay, gap-filler radar input, "cross tell" equipment that makes it possible for one SAGE Direction Center to "talk" to another Direction Center, and manual input equipment enabling AF personnel to communicate with the computer.

The gap-filler radar was developed so that it would be feasible to operate the units unattended.

Computer Programming

Preparing the SAGE Direction Center's high-speed electronic computer to process air defense data is one of the two major responsibilities of the System Development Corporation (SDC), Santa Monica, Calif.

A unit with the engineered ability to follow orders and a vast capacity for remembering lists of data, when the orders and the data are coded in the mathematical language of the computer, it can deal with air defense information in fractions of seconds. Programs involving nearly 250,000 orders, or instructons to the computer, have been designed, prepared, and installed in its "memory" by SDC programmers. Television-type screens then display radar and other air defense data to the AF operators as the computer and its program quickly process incoming reports.

The second phase of the company's work in SAGE concerns the people on the Direction Center's air defense team. The training session utilizes "packaged air raids" created for the SAGE System training program. The computer actually displays tracks of aircraft for the operators to see on their scopes which have all the characteristics of real flights including rates of climb and descent, speed changes, turns, and other maneuvers.

Continental Detection

An important role in the North American Air Defense Command's (NAADC) continental detection system is played by the radar systems for land, air, and sea duty built by the General Electric Company (GE). These radar systems are another vital link in the chain of continental defense.

Used in combination with search radar, the GE built *FPS-6* height-finding radar systems supply the several SAGE Sectors with long-range, accurate height information on approaching aircraft and other air targets. Nodding up and down, the searchlight-like beam is capable of detecting air targets approximately 200 miles away.

Input data (distance, altitude, and flight direction of aircraft) for the giant bank of computers in the first operational SAGE Direction Center at McGuire Air Force Base, Trenton, N.J., is relayed via telephone lines from radar detection sites in eastern Pennsylvania, southern New York, and New Jersey.

Extending the ADC's early warning detection system far beyond the continental shoreline are the airborne systems in military versions of the Lockheed Super Constellation. Designated as *RC-121* by the U.S. AF and *WV-2* by the U.S. Navy, these planes maintain a constant vigil. By carrying a powerful search radar up several thousand feet, picket planes can detect low-flying aircraft over the horizon long before surface radar equipment.

These search radar units, with antenna

housed in a large "bathtub" radome under the plane fuselage, detect aircraft, then operators plot the course, and information is relayed back to the shore where the data is sent to the NAADC, Colorado Springs, Colo.

Currently, the AF has operational squadrons of *RC-121* planes on the East and West Coasts. The Navy's AEW planes are acting as sea extensions of the DEW Line. The AF integrates capabilities of the AEW airplanes into the SAGE System, and makes spontaneous use of the information to direct interceptor planes to the target. The Navy also has the capability of perfoming radar search duties using helicopters and blimps carrying these GE units.

Navy radar picket ships equipped with long-range high-power *SPS-8* height-finding radar systems patrol the mid-ocean and off-shore lines in both the Atlantic and Pacific Oceans. Information received from these electronic systems is relayed to land-based air defense centers for immediate action.

Operation

Th GE d-c power supply system for the SAGE *AN/FSQ-7* computers is made up of two main systems:

1. The duplex system consists of three cubicles each measuring 5 by 6 by 7 feet and has 11 regulated output voltages ranging from 10 to 600 volts and up to 450 d-c amperes. The total d-c kw rating is 125, all of which is regulated.
2. The simplex system also consists of three cubicles, each measuring 5 by 6 by 7 feet. However, there are only 10 output voltages at currents ranging from 10 to 560 amperes. The total kw rating is 130.

An output, consisting of approximately 5 kw of regulated 1,440-cycle a-c power is used only within the power supply system itself. It feeds the first- and second-stage amplifiers of all the d-c power supplies in a given duplex or simplex system. The 48-volt supply, basically used for relay power, does not use this 1,440-cycle output because its regulation requirements are less stringent. The reason for designing the system with this high-frequency power source for use in the first two amplifier stages was to decrease power supply response time to load or line fluctuations and to reduce the required amount of shunt filtering as well as the size of the first- and second-stage amplifiers.

In each system, a semimodular design approach was taken. The first- and second-stage amplifiers are positioned on roll-out chassis, with the remaining system parts modularized for ease of assembly, servicing, and repair. The input feeds a separate power transformer for each supply. This transformer changes the 480-volt input to the level necessary for each power supply output. Each power transformer output then feeds a set of six toroidal-wound power reactors, which are the "adjustable" value in the system. A variation in control signal causes a change in voltage into the next rectifier. Following the reactors are the selenium rectifiers and the shunt filter, which filters the d-c output from the rectifiers and provides sufficient shunt energy to absorb transients until the reactor stages have time to respond to changes in input line or load.

A small signal is taken from the output and fed into a mixing stage where it is compared with a fixed voltage reference, and an error or difference signal is generated. This signal is then amplified twice and fed into control windings of the toroidal power reactors where the output voltage is adjusted accordingly. Each d-c voltage is produced in the same manner in both duplex and simplex supply systems.

Transistorized Indicator

One of several manufacturers involved in SAGE is the Lewyt Manufacturing Corporation, Long Island City, N. Y. Its contribution is a transistorized indicator that displays and provides a printed record of important selected air defense information.

The indicator is known officially as Co-ordinate Data Monitor *OA-1163*. Engineers refer to it as RAPPI, an abbreviation which is an easy one-word identification.

In addition to being able to display target information of a random nature at the correct range and azimuth, RAPPI has the facility to record the co-ordinates of selected targets on paper tape by means of a small gating circle, maneuverable over the entire display, which prints the azimuth and range co-ordinates of the target in decimal form.

Essentially, RAPPI is a piece of test equipment which monitors signals as produced

HUGE PANEL of electronic equipment, made by Bendix Aviation Corporation, is part of input system of SAGE, translating incoming data into computer language. Electronic complex of this portion of system uses 11,471 vacuum tubes and over 30 miles of circuitry.

by the *AN/FST-2* and transmitted through the DDT, the telephone lines, and the DDR. To establish the confidence in the monitor required for these important system tests, RAPPI can self-generate a comprehensive set of test patterns which check the operation of practically all of its circuitry. No external equipment or signal source is required for these tests.

Logical events occurring in RAPPI are sequenced by independent programs generated from the two sets of telephone line signals. The coded target data from these lines are accepted in corresponding shift registers to effect a serial-to-parallel conversion. While in the shift register, the data are examined for agreement with several logical conditions imposed by the monitor. Some of these conditions are always present, while others are dependent upon the front panel settings made by the operator. Thus, should the operator select a particular range interval for magnification, targets falling outside this interval will be rejected. Data arriving while the "main" storage is occupied is placed into an interim "auxiliary" storage.

Relays of the decoder section arrange a set of precision resistors to translate the coded polar co-ordinates of the target. These voltages are amplified and then applied to the two coils of the stationary deflection yoke to position the beam of the display tube correctly. Because other relays control quadrant selection by arranging the phase of each coil, the decoder output is always a positive voltage.

Other circuits perform a decimal conversion of the coded data for the print-out facility, and still others generate the test patterns necessary to self-check the equipment.

Area Responsibility

In the New York area of responsibility —portions of a six-state section along the eastern seaboard—44 million persons rely on NYADS for defense against enemy attack by air. The states included in this densely populated and highly industrialized Sector are parts of New York, Connecticut, Rhode Island, Delaware, and Pennsylvania as well as the entire State of New Jersey.

The NYADS headquarters are maintained at McGuire AF Base with a complement of 5,000 officers and airmen at McGuire and five other bases in New Jersey, New York, and Delaware. Col. C. G. Chandler, Jr., a veteran of 20 years in the AF, including being a jet pilot, heads up the entire operation. He also commands the Continental Air Defense (CONAD) Sector–New York. In the event that an actual enemy attack occurs, as CONAD Commander, he would exercise operational control over air defense units which include Army missile (Nike) sites, anti-aircraft units, Air National Guard augmentations, AF Reserve units, and certain types of U.S. Navy units.

Along with a core of highly trained officers and airmen, Col. Chandler employs what is known in AF terminology as "hardware." The SAGE System, which is now operational, is the newest in the hardware line. Another part of the hardware takes the form of radars operated by NYADS, Data Link, BOMARC, etc.

This combination of the latest developments in hardware in the NYADS area together with the best specialists and techicians available adds up to a mighty fine team—insurance against surprise attack.

Wear Your ◆ AIEE Badge

Digital Computers Simulate and Test Television and Speech Research Devices

THE USE of general purpose digital computers in the simulation of new coding and transmission devices shows promise of accelerating and broadening speech and television research, according to several papers presented recently at the Western Electronics Conference in Los Angeles. In these papers, scientists working in acoustics and television stated that for many laboratory studies it is now possible to avoid construction of very complicated equipment through the use of such simulation.

Complex experimental apparatus must often be built to test theories or design concepts in speech and television research. In the experimental stage, it is frequently difficult to distinguish equipment errors from theoretical deficiencies, which consume time and money.

Simulation of new devices by large-scale digital computers can greatly reduce expense and time lags and, thus, make it easy to investigate a large number of approaches to coding and transmission problems. It even becomes feasible to investigate highly speculative methods which might otherwise have to be ignored. One of the greatest virtues of simulation, however, is versatility, according to the authors, who emphasized that computers can simulate any explicit operation on a speech or video signal.

Speech Research

Drs. E. E. David, M. V. Mathews, and H. S. McDonald, all of Bell Telephone Laboratories, Murray Hill, N. J., described the use of computers in speech research. Speech is sampled, each sample is quantized into 10 bits or 1,024 amplitude levels and delivered to a magnetic tape recorder. These coded samples are recorded in seven parallel tracks, with 200 characters to the inch of tape. These tapes are then fed into the computer, where they are processed according to pre-assigned programs based on the coding or transmission scheme being investigated. The processed signals are then re-recorded, decoded, and played back for analysis and listener evaluation.

PREPARING to photograph a reproduction of a television picture following processing by computer simulation, is R. E. Graham, Bell Telephone Laboratories, while E. E. David, also of Bell Laboratories, adjusts the monitor controls.

Computer memory requirements for speech processing are severe because of the large amount of data generated by even a short section of speech. Rapid access memory units must have a capacity of several seconds of speech to be useful. For example, an 8,000 32-bit word memory can conveniently hold only about 2.4 seconds of speech, at a sampling rate of 10,000 ten-bit samples per second.

A speech transmission scheme known as the "Extremal" method has been studied at Bell Laboratories extensively by simulation, and illustrates graphically the advantages of the new technique. In its simplest form, only the extremes, or peaks and valleys, of a speech wave are sampled. The amplitudes and time of occurrence of these points are then transmitted, instead of a detailed representation of the entire wave. At the receiver, an approximation of the speech wave is generated by interpolating a suitable mathematical function between these points.

Listener evaluation of the simulated speech produced in initial tests showed that intelligibility is high—above 90% sentence intelligibility—but that the quality is somewhat below that of commercial telephones.

This extremal program operated on about a 20 to 1 time scale; for the results reported so far, a total of 5 minutes of speech was synthesized. Including "debugging," about 3 hours of computer time was expended at a cost of $1,500. About four man-months of time was spent, partly in programming, but mostly in determining what to investigate. These figures are substantially less than required to build an actual laboratory model to perform the same function, roughly 1½ man-years and $50,000 in equipment costs. This model also would have been much harder to de-bug, and would have been relatively inflexible.

Digital simulation has been applied to a number of other speech problems at Bell Labs. These include the design and evaluation of delta-modulation coders, pulse-code-modulation systems, detection of vocal pitch, and automatic recognition of speech.

Television Coding

Picture coding research has also been carried on by computer simulation. R. E. Graham and Dr. J. L. Kelly of the Laboratories described a technique which has been used to evaluate a number of proposed television coding schemes, and to improve others. In order to hold machine time and memory requirements to a reasonable level, their system has used an input picture of 100 x 100 elements, corresponding to an area about 1/25 that of a conventional television frame. This 10,000 element "window" has proved to be of sufficient size to allow critical evaluation of the processed images. For typical coding schemes, the total computer time required is 5 to 10 seconds per picture.

A magnetic tape recording of the video signal is prepared by scanning a square picture with 100 scanning lines in 2.4 seconds. Each picture dot is quantized to 10-bit accuracy, providing 1,024 amplitude levels, and recorded in the same form as the previously described speech samples. The resulting signal is rooted, mixed with a synchronizing waveform in the conventional manner, and band limited to 2,500 cps.

In playback, the computed picture signal is converted back to analog form. It is then passed through a low-pass filter, and displayed on a monitor with two kinescope tubes. One of these tubes has a slow phosphor for direct viewing, while the other has a fast phosphor for photography.

A coding scheme which may have widespread significance in television transmission, known as "predictive quantizing," has been studied by both simulation and conventional methods by Mr. Graham. This scheme takes advantage of the relatively low level of viewer perception during periods of scene change or motion, and in areas of picture confusion, these being the only regions in which predictive coding systems make significant errors. The method involves quantizing the difference between the original continuous signal and a predicted version of that signal. It employs fine quantum steps for small errors, and coarse steps for large errors, where the predictor and the viewer are surprised. This tapering of steps in the quantizing staircase allows the use of a smaller number of total levels, and thus reduces the channel capacity requirements.

A limiting case of predictive quantizing, in which the predictor is simply a one-sample delay, has been tested both with the simulation equipment described and with standard 525-line television, and found to afford a picture not significantly degraded from the original, and requiring only three bits per picture dot.

Computer simulation has provided a method for the investigation of a number of variations of predictive quantizing, as well as other methods of coding. Its use in picture analysis for pattern recognition, and for statistical computations as well is also being studied by the authors.

Space Science Board Established by NAS–NRC

Dr. Detlev W. Bronk, National Academy of Sciences–National Research Council (NAS–NRC) president, announced formation of a 16-man Space Science Board ". . . to survey in concert the scientific problems, opportunities and implications of man's advance into space."

Dr. Lloyd V. Berkner, president of As-

sociated Universities, Inc., president of the International Council of Scientific Unions, and a member of the NAS, has been named chairman.

The Board, in addition to acting as the focal point for all NAS–NRC activities connected with space-science research, will be called upon to co-ordinate its work with appropriate civilian and Government agencies, particularly the proposed National Aeronautical and Space Agency, the NSF, and the Advanced Research Projects Agency, and with foreign groups active in this field.

Dr. Bronk stated that the formation of the Board was of special significance for science as it faces the challenge and adventure of the new steps into space. It is his hope that the Board will give fullest possible attention to every aspect of space science, including both the physical and the life sciences. Dr. Bronk further stated that NAS–NRC has a unique opportunity to bring togther scientists from many fields to find ways to further a wise and vigorous national scientific program in this field.

The functions of the Board will include studies of scientific-research opportunities and needs opened up by the advent of modern rocket and satellite tools, advice and recommendations on space science to interested agencies and institutions, stimulation of research interest in the rocket and satellite fields, and co-operative activities in this area with academies and similar institutions abroad.

Eleven ad hoc committees have already been organized to carry on the work of the Board under Dr. Berkner's leadership. These Board member committees, together with their chairmen and vice-chairmen follow:

1. *Geochemistry of Space and Exploration of Moon and Planets*—Dr. Harold C. Urey, professor of chemistry, Univ. of Calif., La Jolla, chairman; Dr. Harrison S. Brown, professor of geochemistry, Calif. Inst. of Tech., vice-chairman.

2. *Astronomy and Radio Astronomy*—Dr. Leo Goldberg, chairman, department of astronomy, Univ. of Mich., chairman.

3. *Future Vehicular Development* (beyond vehicles immediately available and including possible space stations and interplanetary vehicles for scientific research)—Dr. Donald F. Hornig, professor of chemistry, Princeton Univ., chairman.

4. *International Relations Field* (coordination with International Council of Scientific Unions and other national scientific bodies on problems in international sharing of payloads, international co-operation in space activities and advice on the formulation and effects of regulatory policies)—Dr. W. A. Noyes, dean of graduate school, Univ. of Rochester, chairman.

5. *Immediate Problems* (space laboratories, orbits, currently feasible research projects, and liaison with the Technical Panel on the Earth Satellite Program of the U.S. National Committee (USNC) for the International Geophysical Year (IGY) during terminal phases of IGY)—Dr. R. W. Porter, chairman of the USNC–IGY Technical Panel on the Earth Satellite Program, and consultant–communication and control, engineering services, General Electric Co., New York, chairman.

6. *Space Projects* (analysis of advanced space research proposals and long-range planning)—Dr. Bruno B. Rossi, professor of physics, Mass. Inst. of Tech., chairman.

7. *Ionosphere* (experiments pertaining to auroral and ionospheric effects, including whistlers and special propagation phenomena)—A. H. Shapley, physicist, National Bureau of Standards, Boulder, Colo., chairman.

8. *Physics of Fields and Particles in Space*—Dr. John A. Simpson, professor of physics, Univ. of Chicago, chairman; Dr. James A. Van Allen, head, department of physics, Iowa State Univ., vice-chairman.

9. *Future Engineering Development beyond Available Facilities* (telecommunications, telemetry, guidance, environmental conditions, and advanced laboratory requirements)—Dr. O. G. Villard, Jr., professor of electrical engineering, Stanford Univ., chairman.

10. *Meteorological Aspects of Satellites and Space Research*—Dr. Harry Wexler, director of meteorological research, U.S. Weather Bureau, chairman.

11. *Psychological and Biological Research*—Dr. H. Keffer Hartline, biophysics section, Rockefeller Inst. for Med. Research, chairman; Dr. S. S. Stevens, professor of physics, Harvard Univ., vice-chairman.

A twelfth committee, on Geodesy, will be chaired by a Board member still to be selected.

In describing how the Board would seek to accomplish its tasks, Dr. Berkner said, "To insure the development of United States space science on a broad base, we shall encourage the participation of scientists from universities and private research institutions. While Government participation is essential, we feel that it would be unwise if space science were to be developed entirely within the bounds of Government activity.

"We shall encourage participation from all fields of science and . . . when advisable, the integration of similar proposals and the elimination of those that are inappropriate."

AEC News and Notices

AEC To Supply Plutonium for Foreign Research. Announcement was made recently by the U.S. Atomic Energy Commission, (AEC) that the United States will make sufficient quantities of plutonium available for those nations and institutions abroad which desire to use subcritical assemblies in developing their research training programs for peaceful applications of nuclear energy. The subcritical assemblies will not sustain a chain reaction and, therefore, are not real reactors. However, through the use of a neutron source to sustain fission, experiments valuable in studying reactor technology can be made.

Most of the Agreements for Cooperation now in effect limit to 10 grams the amount of plutonium that can be transferred. Experience has shown that a neutron source using plutonium and beryllium is the most satisfactory for subcriti-

Future Meetings of Other Societies

Society for Applied Spectroscopy, joint ASTM Committee E-13, Annual Meeting and Instrument Exposition, Nov. 5-7, Hotel New Yorker, New York, N.Y. Paul Lublin, Sylvania Electric Products Inc, Bayside, N.Y.

IAS, Texas Section, National Specialist Meeting on Dynamics and Aeroelasticity, Nov 6-7, Texas Hotel, Ft Worth, Texas. IAS, 2 E 64 St, New York 21, N. Y.

The Institute of Radio Engineers
5th Annual Meeting, Professional Group on Nuclear Science, Nov 6-7, Villa Motel, San Mateo, Calif. S. J. Reisman, Lockheed Missile Systems Division, Palo Alto, Calif.
Convention, Region 3, Nov 17-18, Atlanta-Biltmore Hotel, Atlanta, Ga. B. J. Dasher, Schl of Elec Eng, Ga Tech, Atlanta 13, Ga.
56th Meeting, Acoustical Society of America, Nov 20-22, Chicago, Ill. Karl Kramer, 3839 Grand Ave, Western Springs, Ill.
Mid-America Electronics Convention, Kansas City Section, Dec 9-11, Municipal Auditorium, Kansas City, Mo. Robert Modrcin, W. E. Fry & Co, 406 W 34 St, Kansas City 11, Mo.

Steel Founders' Society of America, 13th Technical & Operating Conference, Nov 10-12, Carter Hotel, Cleveland, Ohio. G. K. Dreher, SFSA, 606 Terminal Tower, Cleveland 13, Ohio.

Southwest Research Institute, joint USAF School of Aviation Medicine, 2nd International Symposium on Physics & Medicine of the Atmosphere & Space, Nov 10-12, SRI, 8500 Culebra Rd, San Antonio, Texas. Reservations: C. W. Smith, SRI, same.

NEMA, Annual Meeting, Nov 10-14, Traymore Hotel, Atlantic City, N. J. NEMA, 155 E 44 St, New York 17, N. Y.

National Association of Refrigerating Engineers Inc, Annual Meeting, Nov 11-13, Kenilworth Hotel, Miami Beach, Fla.

American Mining Congress, Coal Division Conference, Nov 14, Penn-Sheraton Hotel, Pittsburgh, Pa. J. D. Conover, AMC, Ring Bldg, Washington 6, D. C.

AF Office of Scientific Research, joint NAS, NSF, ADI, Conference on Scientific Information, Nov 16-21, Mayflower Hotel, Washington, D. C. HQ, AFOSR, ARDC, USAF, Washington 25, D. C.

NACE, Fall Meeting, Western Region, Nov 17-19, Statler Hotel, Los Angeles, Calif. J. T. Hull, NACE, 1061 M & M Bldg, Houston 2, Texas.

45th National Foreign Trade Convention, Nov 17-19, Waldorf-Astoria Hotel, New York, N. Y. National Foreign Trade Council, 111 Bway, New York, N. Y.

ARS, Annual Meeting, Nov 17-21, Statler-Hilton Hotel, New York, N. Y. D. E. Roberts, ARS, 500 5th Ave, New York 36, N. Y.

SPI, 8th National Plastics Exposition & Annual Conference, Nov 17-21, International Amphitheatre & Hotel Morrison, Chicago, Ill. SPI, 250 Park Ave, New York 17, N. Y.

ASA, 9th National Conference on Standards, Nov 18-20, Roosevelt Hotel, New York, N. Y. ASA, 70 E 45 St, New York 17, N. Y.

ASCE, Conference on Electronic Computation, Nov 20-21, Kansas City, Mo. J. L. Durkee, Bethlehem Steel Co, Fabricated Steel Construction, Bethlehem, Pa.

ASME, Annual Meeting and 23rd National Power Show, Nov 30–Dec 5, Hotels Statler-Hilton, Sheraton McAlpin, and New York Coliseum, New York, N. Y. L. S. Dennegar, ASME, 29 W 39 St, New York 18, N. Y.

EIA, Conference on Reliable Electrical Connections, Dec 2-4, Statler Hilton Hotel, Dallas, Texas. R. G. Roesch, 1068 S Clinton St, Syracuse 4, N. Y.

Overseas

National Physical Laboratory Symposium & Electronic Computer Exhibition, Nov 28–Dec 4, London, England. C. V. Wattenbach, Dictograph Telephones, Ltd., London, England.

cal assemblies, but about 80 grams of plutonium are required per assembly. Therefore, the Commission is willing to raise the authorization for transfers of plutonium under these Agreements to 260 grams, making available sufficient plutonium–beryllium sources for the operation of several such assemblies.

New Agreements for Cooperation will contain the increased plutonium authorization and those now in effect will be open to amendment at the option of the co-operating country.

Reactor Construction Permits. The AEC issued a construction permit to the National Advisory Committee for Aeronautics (NACA) for a research and testing reactor to be built at the Plum Brook Ordnance Works near Sandusky, Ohio.

The 60-mw (heat) reactor is to be used by NACA to further development of reactors suitable for aircraft propulsion, and is scheduled for completion by January 1, 1960.

The reactor is to be of the light water cooled and moderated type. It will be located in a vertical, cylindrical, stainless steel clad pressure tank, 9 feet in diameter and 32 feet high. The Commission has allocated 224 kilograms of uranium-235 to fuel the reactor through 1970. This is a net amount, consisting of Commission shipments to NACA less returns of U-235 in recoverable scrap and spent fuel.

Proposed issuance of a construction permit to Aerojet-General Nucleonics for 10 research reactors was announced. The reactors, known as model *AGN-211*, will be built at the company's facilities at San Ramon, Calif. Each reactor will have a maximum power of 15 watts (thermal). The reactors will be semiportable and have plastic cores. They will be of the pool type, using uranium enriched to 20% in the isotope U-235 as fuel.

Notice of proposed issuance of a construction permit was filled with the Federal Register on July 21, 1958.

Film Program for Geneva Conference. The U.S. motion picture program presented at the 2nd International Conference on the Peaceful Uses of Atomic Energy at Geneva, Switzerland, in September comprised a comprehensive visual presentation of nuclear energy.

The 44 films, most of them in color and with a total projection time of about 15 hours, covered all major nuclear applications and research activities, and were produced by the Commission and by many of its industrial and university contractors. Sound tracks were prepared in English, French, Spanish, and Russian and were heard simultaneously by means of a newly devised sound system, called "Multi-Vox." Earphones available at each seat enabled a listener to select the language of his choice. The United States film program was exhibited in two sections. Seventeen 30- to 45-minute films were turned over to the United Nations for showing at the Palais des Nations, along with those contributed by others of the 61 participating countries.

The remaining 27 short technical films were exhibited in a specially designed four-bay miniature theatre included in the U.S. exhibit building. These films were specifically aimed at supplementing the U.S. technical papers and exhibits programs.

Waste Disposal License. The AEC gave notice recently that it proposes to issue a 2-year license to American Mail Lines, Ltd., Seattle, Wash., authorizing the company to receive and dispose of atomic waste materials. The proposed license will cover by-product material (radioisotopes) and source material (uranium and thorium) packaged by the Boeing Airplane Company, Seattle. Under terms of the proposed license, American Mail Lines will receive the packaged wastes from Boeing at the American Mail Line dock.

Twin Coal Unloader To Serve Electric Power Plant

Erection of a unique "Siamese twin" coal unloading tower, which will serve a new municipal electric power plant of 812,500-kw capacity, is under way in Memphis, Tenn. Actually two towers on a single base, the unloader is designed, and built by Dravo Corporation, Pittsburgh, Pa., will have two welded triangular booms, each with a 13.3-ton capacity bucket, and two sets of operating equipment. Each boom will have a free-digging capacity of 1,300 tons an hour, or an average rate of 850 tons an hour. Coal barges arriving at the plant, located on McKellar Lake off the Mississippi River just below Memphis, can be unloaded two at a time. The exceptional long booms which will extend more than 100 feet beyond the dock face, will permit the buckets trolleys to rack back and forth over two 35-foot wide 1,500-ton barges moored side by side.

When the unloader is digging at top speed, more coal is dumped into the hoppers than can be discharged to the conveyor belts. Thus, a surplus is built up in the hoppers, assuring a steady flow of coal onto the conveyor belts even when the unloading is interrupted for the repositioning or changing of barges. An adjustable d-c voltage control from an a-c power supply makes possible greater horsepower output from the operating

PARTS of coal unloading tower are placed in barges of Dravo Corporation's Pittsburgh yards for shipment to erection site in Memphis, Tenn., where tower will serve new municipal electric power plant. Tower's buckets have 485-cubic-foot capacity.

motors and smoother bucket handling and trolley motion.

In addition to the unloader, the company also is supplying barge-shifting equipment, which positions the barges under the unloader, moving out empties and moving in loaded barges as needed. When the new plant begins operation late this year, Memphis will be generating its own electric power for the first time. Currently, the city is served by the Tennessee Valley Authority. The new facility will be operated by the Light, Gas and Water Division of the City of Memphis.

WELDED triangular boom, one of two, is part of coal unloading tower.

Monophonic Not Monaural

Monophonic is the word to use when discussing high fidelity sound, *not* monaural, according to Abraham Schwartzman, executive secretary of the Institute of High Fidelity Manufacturers. He explained that this represents the viewpoint of leading high-fidelity component manufacturers and editorial authorities in the field. Growing public interest in stereophonic sound reproduction is one reason for the Institute's desire to use uniform terms in order to minimize possible confusion.

Although conventional high-fidelity recording does engrave the same sound or signal on both walls of the record groove,

when reproduced the result is heard by both ears and is thus single-sound or monophonic and not "one-eared" or monaural. The temptation to equate "stereophonic" with "binaural" should be suppressed, Mr. Schwartzman pointed out. The correct term is stereophonic which, freely translated, means "solid sound"—giving an effect of depth and direction.

Netherlands Opens High-Voltage Research Laboratory

At a recent ceremony, the Delft, Holland, firm of N. V. Nederlandsche Kabelfabriek invited Queen Juliana to open its new High-Voltage Research Laboratory. Shortly after the opening day rites, the delegates who had attended the CIGRE Convention in Paris, France, visited the site as part of a technical post-convention tour.

Following World War II, the firm had expanded so that additional facilities became mandatory for the research phase of the work. The new plant makes feasible the research on cables with very high voltages, sometimes combined with high or low or changing temperatures of the cables.

The highest a-c voltage attainable is 900,000 volts, obtained by three single-phase 300-kv 300-kva transformers which can be connected in series. The highest

TRANSFORMER GROUP *(left)* **for 900 kv consists of three 300-kv transformers. Self-induction coils** *(right)* **show two 300-kv units, respectively, isolated for 600 kv and 900 kv each. In foreground is a 500-kv condenser.**

d-c voltage generated by a cascade rectifier is 600 kv. The highest impulse voltage at an energy of 16 kw is 1,400 kv. In addition, a number of transformers for lower voltages are available.

In order to obtain constant and varying temperatures, a number of heating rooms, eight water tanks, and a few heating d-c generators are also available. In two of the rooms, a constant temperature of 40 C can be maintained. Two other rooms reach a maintained temperature of 110 C. In the water tanks, temperatures can be maintained in the range between —10 C through +90 C. Cable cores can also be heated electrically by means of a d-c generator and simultaneously voltage tested, inasmuch as the heating generators are insulated against ground.

In order to conduct terminal studies during rainfall, a rain-simulating installation has been designed.

An effective grounding system is obtained by welding the iron in the heads of the piles to the reinforcing steel of the concrete foundation. A network of copper strips, welded to the reinforcing steel, makes it possible to have proper ground connections at a large number of points in the high-voltage facility.

To safeguard laboratory personnel against the danger of high voltage during tests, a protective installation has been designed and constructed according to an entirely new system. Each door giving access to a high-voltage area is equipped with a lock and fitted with a red, orange, and green lamp. Access to the space is permitted only if the green lamp is on. Orange means the door is locked and the unit in question can be switched on. Red means the high voltage is switched on. If the red or orange lamp is on, or if no lamp is on at all, entry is forbidden—i. e., a positive system has been used here. Moreover, should the door be opened while the voltage is switched on, it will be switched off automatically.

The design and equipment of the laboratory was carried out entirely by personnel of the Nederlandsche Kabelfabriek. With this structure, the plant has been given a laboratory able to meet modern requirements and one which can hold its own, as compared to other large laboratories of western European industries.

Fast-Wave Parametric Amplifier

Development of a fast-wave parametric amplifier of the vacuum tube variety for use in ultrahigh-frequency and microwave radio receivers was recently announced by Zenith Radio Corporation, Chicago, Ill. Typical performance data for the new amplifier are a noise figure of about 1 db and a gain up to 30 db, it was stated. The tube, developed by a team of research physicists headed by Dr. Robert Adler, the company's associate director of research, in co-operation with Dr. Glen Wade of Stanford University, is based on new concepts that involve the removal of noise from a fast wave on a stream of electronics which carries the signal, and the parametric amplification of that wave. The 4-inch long unit and its auxiliary components form "a small package." It requires no cumbersome refrigeration equipment and can be used in connection with existing uhf (ultrahigh frequency) and microwave receivers.

It was felt that the amplifier will extend greatly the effective range of military defense radars as well as those of missile and earth satellite tracking systems; that it can also be used in equipment for long-range communications; and that the tube has possible application in the field of vhf (very-high frequency) and ufh television, where it could produce substantial improvements in areas where reception is marginal. The amplifier is said to be completely unilateral and unconditionally stable. The new development utilizes an idea advanced by Dr. Adler in which a certain mode of motion on an electron beam (the so-called fast wave) permits interchange of input signal and beam noise in a coupler. In conventional amplifiers where all external power is supplied in the form of direct current, the fast wave cannot be used. In the new amplifier, the fast wave is amplified with the help of externally applied alternating fields, a method which is one form of what has recently come to be called parametric amplification.

An electron gun in the tube, similar to the gun used in picture tubes, generates an electron beam of about 35 microamperes which drifts at very low velocity, corresponding to only 6 volts, along the lines of a 200-gauss magnetic field. Input and output couplers are tuned to the center of the signal frequency band, about 560 mc. The electron beam enters the input coupler with a certain amount of random motion. The fast-wave component of this motion is given up to the input coupler and transformed into heat in the resistive portion of the signal source. At the same time, the beam absorbs signal energy and carries it in the form of a fast wave, thus interchanging beam noise and input signal.

The spiraling electron motion which carries the signal is amplified during passage through the quadrupole electrode, a structure that resembles the stator of a 4-pole generator. It produces a highly nonhomogeneous transverse electric field of fourfold symmetry. The quadrupole is connected to the "pump" which supplies about 10 milliwatts at about 1,120 mc. One component of the alternating nonhomogeneous field pattern in the quadrupole appears to revolve in synchronism with the spiraling electrons; this causes the radius of their orbits to increase or decrease exponentially, depending upon their phase at the instant of entry. When the two processes are averaged, exponential growth always outweighs exponential decay and gain results.

Regardless of how the signal frequency is altered, the individual electrons always spiral through the quadrupole at a rate

FAST-WAVE AMPLIFIER, shown here in laboratory check by Dr. Robert Adler, Zenith's associate director of research, will increase sensitivity of uhf and microwave receivers.

of rotation determined by the magnetic field. As a result, the signal frequency does not affect the amplifying process and the bandwidth is limited only by the input and output couplers. The gain for which the pump power is adjusted has no effect on the bandwidth.

Electronic Detective Protects Shopping Center

The new Southdale Shopping Center outside of Minneapolis, Minn., boasts a unique central detection center that spots fires, intrusions, or machinery breakdowns instantly. The complete 75-store shopping center is monitored around the clock by a network of 165 annunciator points designed by the Scam Instrument Corporation, Chicago, Ill. The maintenance-free annunciator network keeps watch 100% of the time and even keeps watch on itself for possible malfunction

A centralized "protection office" houses a system of audible and visual alarms in a modern control desk. The instant an off-normal condition develops anywhere in the 670,000 square feet of shopping space, an alarm sounds and a sign lights up telling the exact location of the disturbance. Loudspeakers broadcast coded messages to patrolling guards telling them to investigate the scene of the disturbance and report back to the protection office by telephone. This system of cross-checking between the annunciator and the patrolling guard has proved so effective as to require very few personnel on the patrolling guard staff. The amount of time that will elapse between sounding of an alarm and the call-back of the guard is within 60 seconds.

In measuring the efficiency of the annunciator detection system, it was estimated that since the opening of the shopping center in November 1956, more than 22 fires have been detected, many machinery malfunctions spotted before damage could be done, and intrusion has been detected in every instance even when shop owners have failed to inform the protection office of situations where entrance was authorized by persons doing work on off hours.

The special detection network was developed from systems that have been used for years in industrial manufacturing and maintenance, using annunciators sensitive to various stimuli such as heat, motion, stoppage of motion, lack of heat, moisture, and dryness. The air-conditioning and heating systems for the vast amount of floor space are monitored for proper temperatures and the proper functioning of the blowers, generators, and vast array of other machinery for the proper operation of the heating and air-conditioning system.

ANS President Elected at Annual Meeting

Dr. Chauncey Starr, vice-president of North American Aviation, Inc., and general manager of its Atomics International Division, was elected president of the American Nuclear Society (ANS) at the organization's annual meeting recently.

The ANS, formed in 1955 to advance nuclear science and engineering and to encourage research, the establishment of scholarships, dissemination of technical information, and similar pursuits has a membership of about 3,000 representing many branches of science and technology, and includes persons engaged in research, teaching, consultation, administration, and in the advancement of nuclear science and technology. The members are associated with educational, Government, and research institutions, and with Government contractors and industrial companies. The total membership includes about 140 members from 29 different foreign countries.

Dr. Starr is eminently qualified, having directed atomic energy activities for his company, being a Research Fellow in Physics at Harvard University, and having worked on the Manhattan District project during World War II.

As president of the ANS, Dr. Starr succeeds Dr. L. J. Haworth, director of the Brookhaven National Laboratory.

University Institute on Automatic Data Processing

Evaluation of current developments and experience reports in automatic data processing will be featured at The American University's 5th Institute on Electronics in Management to be held November 3-7, 1958, in Washington, D.C. Planned for management officials of business and Government, the Institute will feature lectures, discussion periods, workshop sessions, films, and case reports.

Among the topics to be treated are economics of electronic data processing, integrated data systems, long-distance communication, small computers for data processing, inventory control, economic sorting operations, forms design for data processing, management reporting through computer systems, automatic character reading, information storage and retrieval, and equipment outlook. Information about registration and program details are available from L. H. Hattery, director, Institute on Electronics in Management, American University, 1901 F St., N.W., Washington 6, D.C. Tuition fee is $90, which includes materials to be distributed for background.

EBWR Simulator

A simulator of the Argonne National Laboratory's Experimental Boiling Water Reactor (EBWR) was exhibited at the 2nd International Conference on the Peaceful Uses of Atomic Energy at Geneva, Switzerland, September 1-13, 1958.

Components of the model, which weighs more than 11,000 pounds, were flown to Geneva and assembled several days before the opening of the world-wide scientific meeting.

The EBWR, one of the first "Atoms for Peace" electric power plants, was designed to test the feasibility of the boiling water reactor in helping to meet the world's anticipated power needs in the next 25 to 50 years.

The simulator, built by Leeds & Northrup of Philadelphia, Pa., for Argonne, showed realistically the mechanisms and principles behind the boiling water reactor.

Designed to produce 20,000 kw of heat with a generator output of 5,000 kw of electricity, the EBWR is considered to be one of the most important reactors in its usefulness as a guidepost for harnessing the atom for commercial production of electricity.

Two members of the Argonne Reactor

AROUND-THE-CLOCK protection against fire, burglary, and machinery failure is afforded vast shopping center outside of Minneapolis by electronic alarm system. Annunciators, shown in a line across top of photograph, light up instantly when an off-normal situation develops, telling exact location of the disturbance.

Engineering Division, V. C. Hall, Jr., and E. A. Wimunc demonstrated the simulator.

The EBWR, water-cooled and water-moderated, boils water directly within the fuel assemblies, and the steam, in turn, generates electric power in a turbogenerator.

During preliminary studies of the boiling water reactor principles, the operations were known collectively as the Borax Experiments. After the feasibility of this type of reactor was established, the EBWR was built to study techniques from a power-plant point of view.

An atomic explosion by the EBWR is said to be impossible, but there is always a possibility of a steam or chemical accident, and a precautionary chamber (called "containment vessel") is necessary because the area is densely populated.

PRESSURE VESSEL for the Argonne EBWR being installed in the reactor containment building. Reactor core has been installed in the lower part of the vessel. Extrusions on bottom are control rod housings. Steam accumulates in the upper part of the vessel.

The reactor core which boils the water is contained within a pressure vessel which is 7 feet in diameter, 25 feet high, and 2½ inches thick, forged of boiler steel with an inside layer of stainless steel. It weighs 60 tons, empty. The vessel is insulated with stainless steel wool. Three inches of water-cooled lead, and several feet of special concrete protect the surroundings from radiation.

The core's normal fuel capacity is 5,670.6 kg, or about 6 tons, of uranium alloyed with niobium and zirconium, cladded (protected) by zirconium and used in plates about a quarter-inch thick, 3¾ inches wide, and 4 feet long.

The "control rods," some of hafnium and others of boron-bearing stainless steel, which will slide into the core and absorb neutrons, thus regulating the atomic reaction, have extensions housed in the projections at the lower end of the vessel.

The core operates immersed in 3,000 gallons (11,600 liters) of water. This may be either "light" (ordinary) or "heavy" water, depending on the experiments; at present the light variety is used.

The reactor produces 60,600 pounds of steam at 600 psig (pressure in pounds per square inch, gauge) and 489 F temperature. The pressure and temperature limits are lower than those of conventional plants so that difficulties with materials will not hinder experimental use.

The turbogenerator is standard in most respects, operating at 3,600 rpm and generating up to 5,000 kw of 4,160-volt 3-phase power.

The demonstration model scales and general arrangement are different from those in the actual plant. The containment vessel is shown ⅛th actual size, the turbogenerator ⅛th, and the reactor's core is about ½ size. Only the control panels are full size; they, of course, are production instruments for use on the reactor.

As the rod is withdrawn, viewers see a simulation of the striking blue-green Cerenkov Effect created by fission. The Speedomax instruments on the control panel begin to record the facts necessary for handling the reactor. These readings come from an electronic analog computer —actual heart of the model.

It is this computer that initiates action which causes the instruments to present simulated pictures of the neutron population, rate of energy release, temperatures, and other conditions. The operator uses these as guides in bringing the model to its simulated proper power level. If a mistake is made that could damage a real reactor, the electronic brains of the model do exactly what they would do for a real reactor—the safety features of the instrumentation automatically take charge until the model is again operating properly. As the entire plant reaches desired output, the operator pushes more buttons on Panel A and automatic controls take charge of routine reactor operation. This releases the operator for general supervision of the plant, as would be done in a commercial power plant. The operator then shuts the model down, and the demonstration is concluded.

REACTOR MODEL OPERATION demonstration at Geneva Peaceful Uses of Atomic Energy Conference begins when operator pushes buttons on control panel (A) to start motors which push control rods out of core (B) which (in the real EBWR core) permits neutron radiation to begin bombarding the atomic fuel in the core, thus splitting fuel atoms and releasing energy. As the simulated fission starts, imitation steam appears in the core and passes into the turbine (C) thus causing the turbogenerator part of the model to appear to rotate and generate electricity. The power-plant instruments (D) are then energized by the analog equipment showing temperatures, pressures, rate of steam flow, purity, etc., for the "steam end" of the turbogenerator and the voltage, frequency, current, etc., of the electrical output.

Silicon Cells Harvest Sun's Energy

Rays from the sun have long been used for heating and cooking, but direct conversion into electric power is a present-day achievement. One of the most recent and dramatic applications for silicon solar cells involves the U.S. Navy's Vanguard satellite on which six clusters of cells were placed symmetrically, converting sunlight of outer space into electric power to operate one radio transmitter.

The cells, manufactured by Semiconductor Division of Hoffman Electronics Corporation, Evanston, Ill., are also used in the Aerobee-High rocket as a "sensor" to activate a motion picture camera that photographs the earth from extremely high altitudes. Outer space is black, so the cells respond only to the relative lightness of earth. As the rocket spins, the solar-celled camera photographs the earth.

The ability of silicon solar cells to respond at a rate of 50,000 impulses per second makes them ideal for use in high-speed air and ground computers.

Solar converters are wafer-thin disks of

extremely pure silicon fused with minute amounts of arsenic and boron which help create electron groupings that provide positive and negative electric fields. After the etching and plating procedure, technicians test each one of the cells individually. The cells are then joined in a series consisting of various sizes and shapes needed to meet requirements of specific applications.

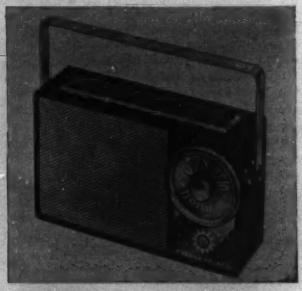
Light photons penetrating the silicon cause the flow of electrons and result in a voltage build-up within each silicon cell. This converted energy is then conducted to whatever outlet has been provided.

The world's first commercial solar cell panel, a 144-cell modular assembly, is designed to supply electric power in multiples of 5 watts. Remote areas without electric power sources may rely on a system of these units for constant power.

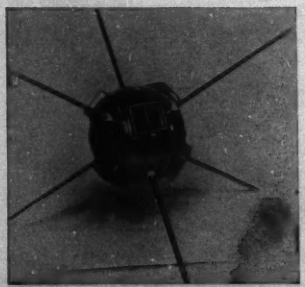
Silicon solar cells have an estimated lifetime of 10,000 years, do not deteriorate, and are virtually unaffected by humidity and temperature variations. They also convert incandescent light into electricity.

Silicon solar converters made today have a top efficiency of about 10%, and are considered ideal for supplying low-power requirements in lieu of heavy, generated electricity.

SOLAR ENERGY CONVERTER, which produced about 20 watts of electricity under direct sunlight, was used to power automatic radio repeater station in test installation arranged with U.S. Forest Service, Santiago Peak, Calif., where it was connected to 12-volt nickel-cadmium battery which stored electricity.



PORTABLE RADIO uses silicon solar cells to convert sunlight or incandescent light into electric power. When neither light source is available, transistorized radio operates from a 100-hour battery charged by the silicon solar converters.



PLACEMENT of solar cell assemblies on surface of U.S. Navy's Vanguard between the antennas was calculated so that cells, produced by Semiconductor Division, Hoffman Electronics Corp., always receive maximum sunlight regardless of sphere's position.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, *Electrical Engineering* reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Illustrations should be submitted in duplicate, one copy and inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Registration Prestige

To the Editor:

It would appear that the article by A. E. Paige ("Your Next Step—Registration," *Electrical Engineering*, June 1958, page 491) deserves far more favorable attention than given by P. J. Klass ("Letter to the Editor," *Electrical Engineering*, August 1958, page 773).

There can be little argument over the statement that registration establishes legal status. Whether or not registration raises individual prestige is another matter. It is noted, however, that the American Medical Association, to which Mr. Klass refers, suffers little damage to its prestige because plumbers, barbers, and cab drivers are ranked as "professional men." The American Medical Association does have prestige—so does the American Bar Association. Prestige is no minor attribute.

Prestige, when applied to an individual, may have its silly aspects, but when applied to a whole group, it has value. If it were not so, the influence of the American Medical Association and the American Bar Association, at our national and state capitals, would be very little. To most of us it would appear that both associations perform a service that is immensely important and helpful to its members. It is not necessarily a service that disregards the welfare of the general public, but it is a service to which Congress and state legislatures may turn for information as well as advice, when they need it. Obviously, such comprehensive advice can seldom be readily obtained, nor is it practical to obtain, from individuals. Be it noted, however, that each "Association" includes practically all practitioners in its membership. This is prestige.

With engineers the situation is somewhat different and the recent "Unity Plan" sponsored by AIEE recognizes it. If the "Plan" is adopted, we will have an operating "Association" comparable to those of the medical and legal professions. Of course, we need our Founding Societies because our divergence of interests are so great. But we will have unified effort in our relations with the public—an area covered by the National Society of Professional Engineers. This group has legal status and is a group of Registered Professional Engineers. It is not a closed organization—a fact that is acknowledged by AIEE as it continues its effort to impress the value of Registration upon all of its members.

Registration does have value and if properly used, has an element of prestige. Improperly used, it, of course, can be ridiculous. Let us not forget, however, that in this age of organization, some group will be recognized as spokesman for engineers. Shall it be a group of Registered Engineers or a Labor Union?

Very truly yours,

HAROLD E. SMITH, P.E. (Member for Life)

NEW BOOKS

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

CLASSROOMS IN THE FACTORIES. By H. F. Clark & H. S. Sloan. Associated College Presses, a Division of New York University Press, 32 Washington Pl., New York 3, N.Y., 1958. 139 pages, 5½ by 8¼ inches, bound. $3.75. This book studies the origin of corporation educational activities, their extent and nature, and the subject matter with which they deal. Approximately 500 of the largest industrial corporations were questioned on their educational programs in the preparation of this report, which is factual in nature and makes no attempt at evaluation.

CONFERENCE ON THE PEACEFUL USES OF ATOMIC ENERGY, 1957 PROCEEDINGS. Co-sponsored by the Japan Atomic Industrial Forum, and by the Atomic Industrial Forum, Inc., 3 E. 54th St., New York 22, N.Y., 1957. 318 pages, 8¼ by 11¾ inches, paper. $5. Following a discussion of the development and uses of atomic energy in Japan and the Far East, there are sections devoted to the economics and technology of power reactor systems; reactor fuels, materials, and components; test, research, and propulsion reactors; application of radiation and radioisotopes in industry; and facilities for handling and working with

radiation. The conference was held in Japan in May 1957.

ELECTRIC CONDUCTION IN SEMICONDUCTORS AND METALS. By W. Ehrenberg. Oxford University Press, Inc., 417 Fifth Ave., New York 16, N.Y., 1958. 389 pages, 6¼ by 9½ inches, bound. $10.10. The author analyzes electric conduction in terms of mobility and diffusion, particle statistics, and wave mechanics. He continues with lattice vibrations and the time of relaxation, ionic lattices, and the linear properties of semiconducting materials. This is then used as a framework for a discussion of rectifying barriers, carrier injection, and transistor physics.

ELECTRONIC COMPONENTS HANDBOOK, VOLUME 2. Edited by Keith Henney and Craig Walsh. McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 36, N.Y., 1958. 375 pages, 8¾ by 11¼ inches, bound. $12.50. The components covered in this handbook are power sources and converters, fuses and circuit breakers, electric indicating instruments, printed wiring boards, solder and fluxes, choppers, blowers, r-f transmission lines, and waveguides. The book gives information useful in selecting and applying the best unit for a particular job in order to achieve maximum reliability of the end product. The effect of unfavorable environment on each component is examined, and a digest of the military specifications for each type of component is given.

ENERGY IN LATIN AMERICA. Prepared by the Secretariat of the United Nations Economic Commission for Latin America. Columbia University Press, 2960 Broadway, New York 27, N.Y., 1957. 268 pages, 8½ by 11 inches, paper. $2.50. Beginning with a statement of the problems involved, this study continues with recent developments in the consumption of energy. An analysis is made of the changes in consumption by forms of energy, the consumption of energy by economic sectors, energy resources, efficiency in the use of energy, and financial aspects. It concludes with the energy supply and demand prospects for 1965.

ENGLISH–RUSSIAN, RUSSIAN–ENGLISH ELECTRONICS DICTIONARY. By the U.S. Department of the Army. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N.Y., 1958. 943 pages, 6¼ by 9¾ inches, bound. $8. This comprehensive work translates 22,000 Russian terms into English and 25,000 terms from English into Russian. It covers virtually every aspect of electronics, and its use is facilitated by the fact that Russian verbs are given in both imperfective and perfective forms. Soviet terms which have no equivalent in Western terminology are explained, and an extensive cross-reference system is provided. The work was previously published as Technical Manual *30-545*.

ESTIMATING CONSTRUCTION COSTS. By R. L. Peurifoy. Second edition. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N.Y., 1958. 446 pages, 6 by 9¼ inches, bound. $10.75. A practical text outlining various methods of preparing estimates, this edition has been expanded to include more information on bonds, insurance, and depreciation of equipment, as well as new information on stone masonry, house carpentry, interior finish, millwork, wallboard, lathing, plastering, painting, glass, glazing, roofing, plumbing, and electrical wiring. Cost data have been brought up to date throughout.

HOW TO BECOME A PROFESSIONAL ENGINEER. By J. D. Constance. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N.Y., 1958. 272 pages, 5½ by 9¼ inches, bound. $6.50. The underlying philosophy and practice of engineering is presented, and is followed by the practical steps to be taken in securing registered status: qualifying experience, how to prepare for and pass the written examination, and registration by endorsement. A summary of state registration laws, names and addresses of state board secretaries, and a list of recommended texts for use in preparing for examinations are given.

INTRODUCTION TO NONLINEAR ANALYSIS. By W. J. Cunningham. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N.Y., 1958. 349 pages, 6 by 9¼ inches, bound. $9.50. The book discusses methods for obtaining solutions for nonlinear differential equations having a single independent variable. Numerical, graphical, and analytical methods are described; many examples of physical systems are provided to illustrate the techniques of solution and the unusual types of phenomena which may arise. A knowledge of electrical circuits, mechanical circuits, and linear differential equations is required.

Library Services

ENGINEERING Societies Library books may be borrowed by mail by AIEE members for a small handling charge. The Library also prepares bibliographies, maintains search and translation services, and can supply a photoprint of a microfilm copy of any item in its collection. Address inquiries to R. H. Phelps, Director, Engineering Societies Library, 20 W 39 St., New York 18, N. Y.

INTRODUCTION TO NUCLEAR ENGINEERING. By Richard Stephenson. Second edition. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N.Y., 1958. 491 pages, 6¼ by 9½ inches, bound. $9.50. Major emphasis has been placed on those aspects of engineering practice unique to nuclear engineering. This edition contains two new chapters: the first deals with reactor core design and discusses burnout, hot-channel factors, and related problems; the second discusses thermonuclear reactions and the basic principles involved. A number of chapters have been expanded because of the declassification of literature in the field.

LOGIC MACHINES AND DIAGRAMS. By Martin Gardner. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N.Y., 1958. 157 pages, 6 by 9¼ inches, bound. $5. A survey of mechanical and electrical machines designed to solve problems in formal logic is presented. The Stanhope demonstrator, Jevon's logic machine, the Marquand machine, and logic window cards for solving elementary logic problems are described. Applications of electric logic machines to operations research and information storing and processing are discussed.

MAGNETIC TAPE RECORDING. By H. G. M. Spratt. Macmillan Company, 60 Fifth Ave., New York 11, N.Y., 1958. 319 pages, 5½ by 8¾ inches, bound. $8.50. This handbook discusses the principles of magnetic recording and the methods and materials of tape manufacture. Descriptions of tape recording and reproducing machinery are given, and special applications to industrial purposes are treated.

MATHEMATICAL PROGRAMMING. By N. V. Reinfeld & W. R. Vogel. Prentice-Hall, Inc., 70 Fifth Ave., New York 11, N.Y., 1958. 274 pages, 6 by 9¼ inches, bound. $9. Primarily designed for industrial personnel lacking advanced mathematical training, this volume stresses practical applications of mathematical programming. In addition to an extensive chapter consisting of case studies, material is presented on the distribution method, Vogel's approximation method, the simplex and its formulation, the relaxation method, and the computer as a means of solution.

MEDICAL ELECTRICAL EQUIPMENT. Edited by R. E. Molloy. Philosophical Library, Inc., 15 E. 40th St., New York 16, N.Y., 1958. 312 pages, 6¼ by 9 inches, bound. $15. An introductory section on the uses of electricity in hospitals and necessary safeguards is followed by sections on various types of equipment, including shadowless light fittings for the operating theater, emergency lighting systems, X-ray apparatus, radioisotope diagnostic instruments, surgical diathermy, endoscopes, electrocardiographs, electroencephalographs, respiratory and suction apparatus, incubators, and sterilizers. The book concludes with a discussion of small electric motors used in medical equipment.

MICROWAVE TRANSMISSION DESIGN DATA. By Theodore Moreno. Dover Publications, Inc., 920 Broadway, New York 10, N.Y., 1958. 248 pages, 5¼ by 8 inches, paper. $1.50. Preliminary material on general transmission line theory and on coaxial lines and flexible cables is followed by a discussion of waveguides with particular emphasis on practical structures and components, dielectric materials and their properties at microwave frequencies, and cavity resonators. This is a reprint of a book that has been unavailable for some time.

MIKROWELLEN-MESSTECKNIK. By F. J. Tischer. Springer-Verlag, Berlin, West Germany, 1958. 310 pages, 6¼ by 9¼ inches, bound. 54 DM. The author discusses the methods and equipment for the measurement of frequency, power, and impedance in the microwave field. He also deals with waveguides, cavity resonators, ferrite elements, field strength and field distribution measurement, and noise measurement.

OPERATIONAL MATHEMATICS. By R. V. Churchill. Second edition. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N.Y., 1958. 337 pages, 6 by 9¼ inches, bound. $7. The operational properties of the Laplace transformation are developed in considerable detail in this publication. This is followed by the operational mathematics for various Fourier transformations and their generalizations, and the theory and applications of eigenvalue problems. Applications are illustrated through problems in engineering and physics involving differential equations, such as vibrating mechanical systems, electric circuits, and servo-mechanisms.

THE SOLID STATE FOR ENGINEERS. By M. J. Sinnott. John Wiley and Sons, Inc., 440 Fourth Ave., New York 16, N.Y., 1958. 522 pages, 6 by 9¼ inches, bound. $12.50. Intended to acquaint engineers with the basic principles underlying the behavior of solid materials, the book discusses crystallography; thermodynamic stability of solid structures and rates of change between states; types of solids: metallic, ionic, covalent and molecular; elastic and plastic deformation; mechanical properties of solids; electron and zone theories; electronic conduction, semiconduction, and insulation phenomena; and optical properties of solids.

SOLID-STATE PHYSICS. Supplement 1: Nuclear Quadrupole Resonance Spectroscopy. By T. P. Das and E. L. Hahn. Academic Press, Inc., 111 Fifth Ave., New York 3, N.Y., 1958. 223 pages, 6 by 9¼ inches, bound. $7. Emphasizing pure nuclear quadrupole interactions with crystalline and molecular electric fields, the authors place magnetic interactions in a minor role. Part one deals with the phenomenological theory for the frequencies of the quadrupole spectra, the nature of their Zeeman patterns, the line shapes and line widths, and the relaxation times. Part two deals with the experimental apparatus required, and part three is concerned with interpretation of experimental results.

SOUND PULSES. By F. G. Friedlander. Cambridge University Press, 32 E. 57th St., New York 22, N.Y., 1958. 202 pages, 5½ by 9¼ inches, bound. $7.50. This publication describes the theory of sound pulses as based on the theory of linear partial differential equations of hyperbolic type. Aspects dealt with are the equations of motion, wavefronts and characteristics, geometrical acoustics and their application to reflection problems, and the diffraction of a pulse by a wedge, circular cylinder, sphere, and other objects.

SPACE FLIGHT. By C. C. Adams. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N.Y., 1958. 373 pages, 5½ by 8¼ inches, bound. $6.50. This is a clearly written account of the past and present status of space travel. The first half of the volume is devoted to a historical review and to the astronomical and engineering fundamentals of astronautics. The latter half is concerned with the problems to be faced in the future, such as the human and biological factors of space flying, communications, and navigation.

SYMPOSIUM ON NONDESTRUCTIVE TESTS IN THE FIELD OF NUCLEAR ENERGY. Published as Special Technical Publication No. 223 by the American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa., 1958. 395 pages, 6 by 9¼ inches, bound. $10. This collection of papers surveys ultrasonic, radiation, and eddy current methods and techniques. The majority of the papers included discuss applications in the inspec-

tion of castings, tubing, unclad fuel element components, and clad fuel elements.

SYMPOSIUM ON RADIATION EFFECTS ON MATERIALS—VOLUME 2. Published as Special Technical Publication No. 220, by the American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa., 1958. 137 pages, 6¼ by 9¼ inches, bound. $3.75. Twelve papers dealing with the interpretation of existing code and specification values as they apply to nuclear reactor structures and components are contained in this volume. Two deal with consideration of radiation effects in design, five with radiation facilities and techniques, and five with various materials.

TECHNICAL EDITING. Edited by B. H. Weil. Reinhold Publishing Corporation, 430 Park Ave., New York 22, N.Y., 1958. 278 pages, 5¼ by 7½ inches, bound, $5.75. Presenting the basic concepts and practices of internal communications, journal editing, book publishing, and graphic arts as related to the technical field, the papers in this volume are written by persons engaged in these activities and provide a practical approach to the problems involved in technical editing.

THE TECHNIQUE OF STAGE LIGHTING. By R. G. Williams. Second edition. Pitman Publishing Corporation, 2 W. 45th St., New York 19, N.Y., 1958. 198 pages, 5½ by 8¼ inches, bound. $7.50. The handbook discusses the scientific basis of stage lighting, the adaptation and control of light, the art of stage lighting, and practical lighting for stage productions. This edition brings the information on light sources, color filters, and stage lighting apparatus up to date, as well as providing a more extended treatment of dimmers and lighting control equipment.

TRANSISTOR TECHNOLOGY: VOLUME II. Edited by F. J. Biondi. D. Van Nostrand Company, Inc., 120 Alexander St., Princeton, N.J., 1958. 701 pages, 6 by 9¼ inches, bound. $17.50. Part one discusses the technology of materials with special emphasis on silicon. Part two deals with the principles of device design beginning with diodes and continuing with triodes and the more complex multiple-junction switching devices and tetrodes. Chapters follow on radiation sensitive devices, field effect devices, and on noise behavior. The book concludes with the design implications of surface phenomena.

TECHNICAL LITERATURE

The following recently issued technical literature may be of interest to readers of *Electrical Engineering*. All inquiries should be addressed to the issuers.

CLOSED-CIRCUIT TELEVISION SYSTEMS. This 348-page book explains the fundamentals and techniques of closed-circuit television and presents characteristics and typical applications of various types of commercial equipment. The new book describes factors which assure reliable performance under various environmental conditions, and includes chapters on typical industrial applications as well as technical information prepared originally for the U. S. Air Force. It is available from the Government Service Department of the Radio Corporation of America Service Company, Camden 8, N. J., at $4.50 postpaid.

BIBLIOGRAPHY ON MEDICAL ELECTRONICS. The compilers have broadly defined medical electronics, for the purposes of this bibliography, as comprising any application of any of the branches of electronics, such as acoustics, communications, television techniques, spectrophotometry, or dielectric heating, to any problems of biological or medical research, therapy, public health, and related fields. Designed to serve as source material in the general field of medical electronics, the bibliography is divided into three sections: main (or numerical) listing, subject index, and author index. It was prepared by Medical Electronics Center of The Rockefeller Institute, and published by the Professional Group on Medical Electronics of the Institute of Radio Engineers (IRE). Copies of the bibliography may be purchased at $2.50 per copy from IRE, 1 E. 79th St., New York 21, N. Y.

MANAGEMENT'S STAKE IN RESEARCH. By Maurice Holland, this book, to which nine other research leaders, industrialists, and bankers contributed material, emphasizes the need for the modern business administrator to take full account of industrial research as a critical factor in his company's health. The book, published by Harper & Brothers, 49 E. 33rd St., New York, N. Y., is available at $3.50.

NEMA STANDARDS. The following standards publications of the National Electrical Manufacturers Association (NEMA) are now available for immediate distribution: *Lightning Arresters, Ed. 1-1958*—these standards apply to all valve- and expulsion-type lightning arresters for a-c systems, including arresters which are an integral part of other apparatus. They have been approved by NEMA to provide additional standards and information not included in the American Standard for Lightning Arresters for Alternating-Current Power Circuits, C 62.1-1957, $2.75 per copy. *Mechanical-Drive Steam Turbines, SM 20-1958*—definitions, nomenclature, shipment and installation, and steam piping systems as applied to mechanical-drive steam turbines are covered in SM 20-1958. Detailed information is given for features and accessories, steam pressure, temperature, flow limits, output shaft extensions, protective devices, vibration, connections, casing sealing glands, speed governors, weather protection, and factory test and nameplate data, $2 per copy. *Semiconductor Rectifiers*—the NEMA Standards for Metallic Rectifiers, MR 1-1953, has been completely revised and brought up to date. Each section of this book is now available as a separate publication, as follows: MR 1-1958, Safety Code, 30¢, MR 10-1958, Copper Oxide Cells and Stacks, 50¢. MR 11-1958, Selenium Cells and Stacks, 50¢. MR 20-1958, Cathodic Protection Units, 40¢, MR 22-1958, Electroplating Units, 40¢, and MR 23-1958, Truck Battery Charger Units, 40¢.

BRITTLE FAILURE OF ROTOR FORGINGS, STP 231. Modern rotors of large size used at high speeds demand techniques of a most exacting nature. This symposium, published by the American Society for Testing Materials (ASTM), evaluates some considerations of the problems associated with rotor forgings inspection. It was held at a special meeting for delegates to the World Metals Congress in November 1957. Representatives of six foreign nations participated in this symposium. Contents include: introduction, inspection of large rotor forgings, rotor forgings for power equipment manufacturers, the work of the task group on brittle failure with respect to research, requirements for turbine and generator rotor forgings, influence of geometric factors on results of ultrasonic testing of heavy forgings, and thoughts on the question of axial test boring in rotor bodies. Copies of this book may be ordered from ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa., at $2 each.

ENGINEERING CONSULTANTS. This directory of the American Institute of Consulting Engineers (AICE) contains a list of qualified engineers and their firms, with some biographical data, as well as information concerning the services in the fields in which they serve. Also included is a classified index for convenience in locating engineers for particular types of problems. Copies of the book can be purchased from the AICE, 33 W. 39th St., New York 18, N. Y., at $2.50 per copy for the cloth-bound edition, and $1.50 per copy for the paper-covered one.

EIA STANDARDS. The Electronic Industries Association (EIA) has made available five new recommended standards for the electronics industry. The standards were published following approval by representatives of the industry, including members and nonmembers of EIA. Representatives of EIA member-firms have received the standards, which are available to all segments of the electronics industry. Nonmembers of the Association may obtain copies of the following standards through the EIA Engineering Department, 11 W. 42nd St., New York 36, N. Y. (a minimum charge of $1 is made on all orders): RS-165-A, Ceramic Dielectric Capacitors, Classes 1 & 2, 1,000–7,500 Volt Rating (revision of RS-165), 80¢; RS-207, Television Tuner Performance Presentation and Measurement (new material), 25¢; RS-210, Terminating and Signaling Equipment for Microwave Communications Systems, Part 1: Telephone equipment (new material), $1.10; RS-211, Dimensional Characteristics of Phonograph Records for Home Use, 78, 45, 33⅓ rpm (revision of REC-103), 60¢; and RS-212, Numbering of Electrodes and Designation of Units in Electron Tubes, (revision of ET-113), 25¢.

OTS PUBLICATIONS. A translation of the 1958 edition of "Artificial Satellites (Iskusstvennyye Sputniki)," by A. Shternfeld, a leading Soviet authority, has been made available by the Office of Technical Services (OTS). This new book contains chapters on construction of satellites, life under conditions of weightlessness, harmful radiations and the meteor hazard, the microatmosphere and its conditioning, as well as discussions of various other pertinent topics. The volume, *PB 141351T*, was published by the State Publishing House of Technical-Theoretical Literature, Moscow, USSR, 1958, and was translated by the Technical Documents Liaison Office, Wright-Patterson Air Force Base, Ohio. It may be purchased from OTS, U.S. Department of Commerce, Washington 25, D.C., for $6. The OTS also recently published five catalogs of technical reports, available at 10¢ each: *CTR-343*, Powder Metallurgy, 1929-58; *CTR-339*, Stroboscopy, 1934-58; *CTR-341*, Stereoscopy, 1930-58; *CTR-340*, Semiconductors, 1933-58; and *CTR-342*, Air Conditioning, 1931-58.

PROCEEDINGS OF THE SECOND INTERNATIONAL CONFERENCE ON THE PEACEFUL USES OF ATOMIC ENERGY, 1958. The only complete edition of these proceedings, in English, will consist of: (1) material relating to the objectives and operation of the Conference; (2) the record of all sessions; (3) the complete text of all papers submitted to the Conference (approximately 2,200); and (4) a detailed index volume. Expected to consist of 34 volumes, the first volumes are to be available in December 1958, the last by July 1959. A special prepublication price of $435 is being offered, for which orders must be received by November 30, 1958. (The English edition is expected to have a retail price of $510.) Readers who do not wish to subscribe to the full series may order separate volumes. Orders and requests for additional information should be sent to United Nations, Sales & Circulation (Atomic Energy), New York, N.Y. An Index to the Proceedings of the 1955 International Conference on the Peaceful Uses of Atomic Energy (Volume 17) has been made available and may be ordered, at $6, from International Documents Service, Columbia University Press, 2960 Broadway, New York 27, N.Y.

NEL RELIABILITY BIBLIOGRAPHY. Supplement 1. This report, a reprint of an original document resulting from Government-sponsored research, was issued as part of a co-operative program between the Bureau of Ships and industry to promote reliability in the design and production of electronics equipment. Preparation and dissemination of the bibliography was accomplished through the Navy Electronics Laboratory (NEL), the Bureau of Ships, and the Office of Technical Services (OTS). The pages in the supplement of the bibliography are numbered for interfiling in the appropriate sections of the basic book. There are 10 sections in this volume: circuit design components, electron tubes, failure analysis, general, human engineering, maintenance, mechanical design, systems, and testing. A list of periodicals abstracted is included in the bibliography. Some of the more specialized publications may be available from the activity or company listed in the reference, from the OTS, or from the Armed Services Technical Information Agency, Knott Building, Dayton 2, Ohio. Most of the publications are readily available from technical libraries or the science and engineering departments of large public and university libraries. Copies of the bibliography supplement may be obtained from OTS, Department of Commerce, Washington 25, D. C. Price $3.

NO ROOM FOR ERROR...AT THE COUNTDOWN...

Linear accelerometer needs no heater jacket–reliability and accuracy from

−65°F TO +200°F

When critical missile and aircraft testing demands an accelerometer of accurate, reliable operation over wide temperature range, specify Statham Model A501.

The remarkable design feature of the Model A501 lies in the use of gas damping. This method of damping permits the operation of the unit over a −65°F to +200°F range without use of a heater jacket. It produces–flat up to 500 cycles per second–reliable signals of rapidly changing acceleration.

Statham instruments are specified by leading manufacturers and government facilities...wherever accuracy, reliability, and superiority are required.

For detailed technical data to answer *your* application needs, write for Bulletin Number A501TC.

Range:	±5 to ±50 g
Excitation:	5 volts DC or AC (rms)
Output:	±20 millivolts
Non-linearity and Hysteresis:	Not more than ±1% full scale
Weight:	6½ ounces

accuracy / integrity / reliability

Statham Instruments, Inc. *12401 West Olympic Boulevard, Los Angeles 64, California*

New and Improved Products . . .

All-Transistor D-C Voltmeter . . .

A new, battery-operated, all-transistor d-c voltmeter, developed to measure the low-level potentials inherent in transistor and diode circuitry, is now available from Consolidated Electrodynamics Corporation, Pasadena, Calif. Known as the Alectra Model *30A* d-c electronic voltmeter, it permits d-c measurements in a wide variety of applications ranging from the calibration of simple thermocouples to the testing of complex computers. The new instrument features high input impedance of 2 megohms per volt and eight ranges which permit measurements from 0.05 to 150 volts with accuracy of ±3% full-scale. A chopper-stabilized amplifier is used to achieve maximum stability and low drift. Further information on the Model *30A* appears in CEC Bulletin *7009*. **Alectra Division, Consolidated Electrodynamics Corporation, 300 N. Sierra Madre Villa, Pasadena, Calif.**

Circle 201 on the card.

"Oxalloy 28" . . .

Copper wire clad with a chrome-iron alloy has been developed by Sylvania Electric Products Inc. as an electric conductor for equipment which must operate under high-temperature, corrosive, and oxidizing conditions. Known as *Oxalloy 28*, the new wire is ideal for applications such as leads to heating elements in electric resistance furnaces, electric appliances, and vacuum tubes, and as hook-up wire in electric equipment. **Sylvania Electric Products Inc., Warren, Pa.**

Circle 202 on the card.

Break Resistant Flashlight . . .

A flashlight equipped with unbreakable plastic fittings including an oversized "safety glow" head is now on the market

Courtesy Bakelite Co.

as one of the newest applications of Bakelite high-density polyethylene. Called the Eveready Beacon Lite, its bottom cap as well as its globe-shaped head make use of the improved properties of high-density polyethylene supplied by Bakelite Company. Shock resistance, the manufacturer reports, is the major advantage of the new plastic in this product. High-density polyethylene, combined with the novel design of the flashlight's head, serves to protect the lens and bulb that are recessed within the head itself. Appearance is also enhanced by the high gloss of the molded high-density polyethylene. It can be colored readily and is translucent. **Bakelite Company, Division of Union Carbide Corporation, 655 Madison Ave., New York 21, N. Y.**

Circle 203 on the card.

Metal Pipe Base Redesigned . . .

The Hope metal pipe base for outdoor lighting has been redesigned for greater rigidity between base and pipe upright, easier installation, and prevention of corrosion at the threaded joint. It is available in four sizes with either a plain junction chamber cover or one containing a weatherproof 3-pole receptacle to permit plugging in hand tools, electric mowers, or auxiliary lights. **Hope Electrical Products Co., 39 Long Ave., Hillside, N. J.**

Circle 204 on the card.

Metal Film Precision Resistors . . .

New Ohmite Series 77, metal film precision resistors are now smaller, yet offer higher maximum resistance than the previous models. At the same time, prices of these units have been reduced sharply and are now comparable to, or lower than, quality precision wire-wound units. In the axial lead style, two shapes are now available: a tubular shape and a "flat-side" shape which offers maximum space economy. A radial lead style is also furnished. Resistance range of the line has been increased and is now 25 ohms to 400 kilohms. Standard tolerance is ±1% but tolerances as low as 0.1% can be furnished. A lower standard temperature coefficient of resistance is now provided — 0±25 parts per million per degree C over the exceedingly wide temperature range of —55C to +190C (25C reference ambient). For additional information write for Bulletin *155*. **Ohmite Manufacturing Company, 3695 Howard St., Skokie, Ill.**

Circle 205 on the card.

5-in-1 Plastic Metal Kit . . .

Announcement of a new 5-in-1 plastic metal kit containing one pint of clear Flawmaster epoxy, plus five jars of powdered metals, has been made. With this versatile kit at hand any of the five metal powders may be mixed with the clear epoxy to meet any metallic bonding needs, or the clear epoxy may be used to bond

glass, china, plastic, wood, etc. Kits or descriptive literature are available at present only from the manufacturer. **Carl H. Biggs Company, 2255 Barry Ave., W. Los Angeles 64, Calif.**

Circle 206 on the card.

Luminous Ceilings . . .

A new concept in luminous ceilings, the Infinilite Floating Luminous Panel, has been made possible by the introduction of a finish trim. This development results in lowered costs, and is specifically designed to lower ceiling heights in remodeling and relighting of older offices, apartments, professional suites, etc. **Integrated Ceilings Corp., 9011 Beverly Blvd., Los Angeles 48, Calif.**

Circle 207 on the card.

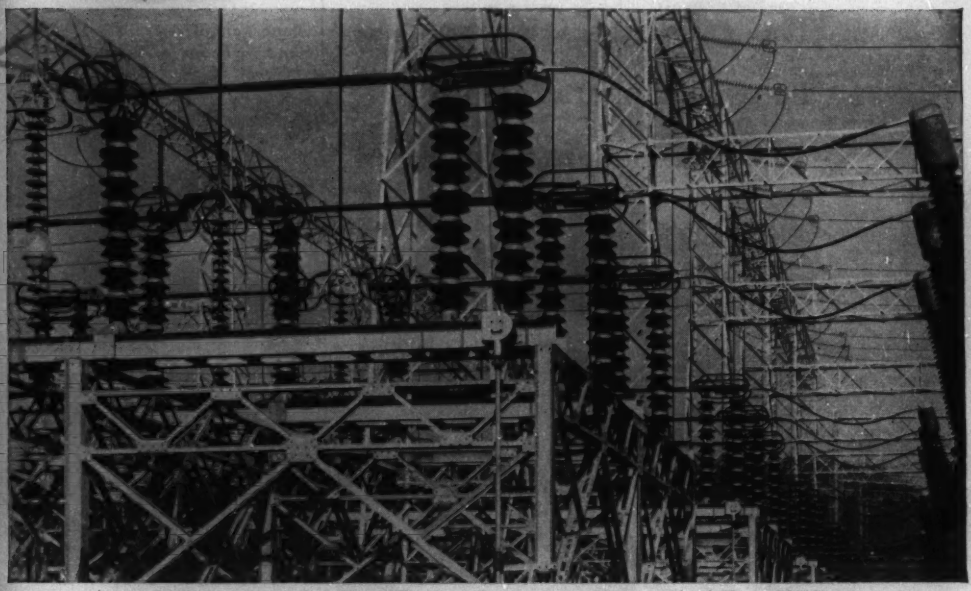
Personal Radio Communications . . .

Another step toward the wrist-radio concept of personal communications has been accomplished in the new "Handie-Talkie" pocket receiver, and accompanying "Handie-Talkie" pocket transmitter. The fully transistorized receiver adds a complete new dimension to 2-way mobile radio systems by extending easy communications capability to the man on foot. The new Motorola pocket receiver picks up all radio signals on a system's frequency, making possible the immediate contact of key personnel in police, fire, military, construction, forestry, refineries, utilities, and manufacturing activities, and any others using 2-way radio. Communications can be maintained with the system's base station or any of its mobile stations. **Motorola, Inc., Communications and Industrial Electronics Division, 4501 W. Augusta Blvd., Chicago 51, Ill.**

Circle 208 on the card.

(*Continued on page 20A*)

R&IE OUTDOOR DISCONNECTING SWITCHES



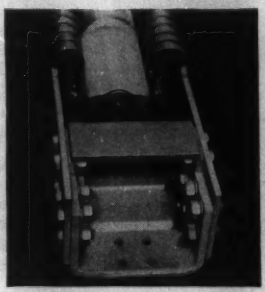
Hi-Pressure Contact Switches at Clifty Creek Station, Indiana-Kentucky Electric Corp. (OVEC).

345 KV SWITCHES FOR CLIFTY CREEK SHRUG OFF 70,000 AMP PUNCH IN JAW

The in-line jaw contacts on these Clifty Creek switches were proved long before they were placed in service. R&IE engineers applied a rigorous test—70,000 amp in three successive jolts. No damage to contacts from erosion, burning or melting resulted, and the powerful electromagnetic forces produced by these high currents caused no movement of the 13 ft. blade.

The features responsible for this trouble-free performance are found on all R&IE disconnect switches, differing only in configuration based on the required short time current rating. All have massive silver-to-copper contacts to maintain low contact resistance and to allow rapid transfer of heat away from the contact surfaces under fault conditions. All have nonannealing beryllium copper contact supports to provide maximum spring force and resilience for efficient current flow and for maximum resistance to electromagnetic forces.

Better designed contacts are only one of the many extra features built into the R&IE switches at Clifty Creek and available to you . . . at no extra cost . . . in a wide variety of R&IE disconnect switches in other ratings from 7.5 kv. Learn how these features can benefit you by contacting your nearby I-T-E sales office. Or write R&IE Equipment Division, Greensburg, Pa. In Canada: Eastern Power Devices Ltd., Port Credit, Ont.



In-line jaw contact for 100,000 amp momentary current. At high currents, magnetic forces increase contact pressure and hold blade stationary.

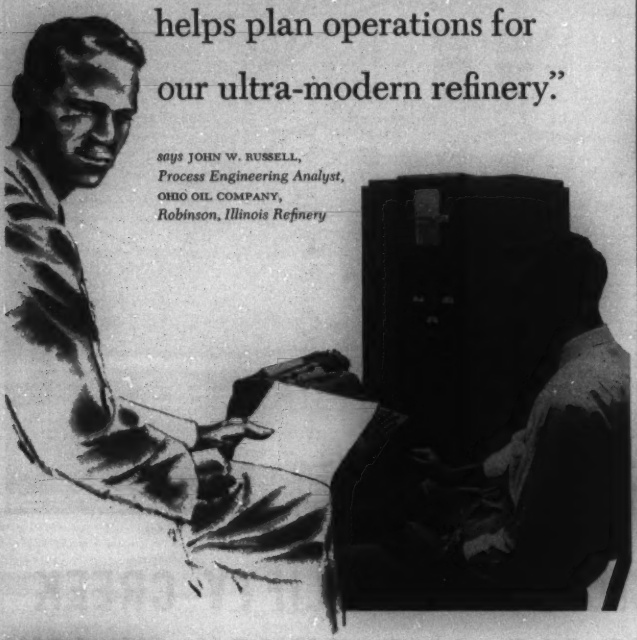
I-T-E CIRCUIT BREAKER COMPANY

R&IE EQUIPMENT DIVISION · Greensburg, Pa.

For more information circle 15 on reader service card.

"The Bendix G-15 computer helps plan operations for our ultra-modern refinery."

says JOHN W. RUSSELL,
Process Engineering Analyst,
OHIO OIL COMPANY,
Robinson, Illinois Refinery



"In the highly competitive oil industry, efficiently planned refinery operation is a must. To handle the complex mathematics involved in this planning, we needed the speed of electronic computing. After careful study, we have installed a Bendix G-15 and although it is one of the lowest priced machines, we are using it very successfully on large scale problems. We like the compact size and have found reliability to be exceptional. G-15 users share valuable programs through their own organization, too, and this adds materially to the computer's value."

THE G-15 PROVIDES – Low-cost versatility for thousands of office and laboratory applications – Simplified operating methods – Memory and speed of computers costing four times as much – Typewriter input-output, paper tape output and 250 char/sec paper tape input at no added cost – Expandability through accessories for 1,200,000 words of magnetic tape storage and punched card input-output – Extensive program library – Users share programs – Proven reliability – Nationwide service – Lease or purchase.

Bendix Computer DIVISION OF BENDIX AVIATION CORPORATION

Built and backed by Bendix, the G-15 is serving scores of progressive businesses large and small throughout the world. For details, write to Bendix Computer, Department K-7, Los Angeles 45, California.

For more information circle 16 on reader service card.

New Products

(*Continued from page 18A*)

Single-Range Precision Hand Tachometer . . .

Ideal for accurate speed measurements in laboratories, test beds, and in quality control or production tests, the dial diameter is 120 mm and the scale calibration is

Courtesy James G. Biddle Co.

therefore conveniently open and easily readable. The 7-mm drive shaft is equipped with ball bearings. The Jagabi precision hand tachometer is supplied with two large rubber mounted male and female centers, an extensive shaft and center, an oil container and dropper, and is in a strong case 9½ inches by 6¼ inches by 3 inches. Total weight is 3¼ pounds. Write for Bulletin *35-7*. **James G. Biddle Co., 1316 Arch St., Philadelphia 7, Pa.**

Circle 209 on the card.

High Efficiency Fixture . . .

The handsome effect of the Prismalume lens against smooth curved lines creates a striking effect in Hector, a fixture series recently announced. The fixture was designed specifically for the Holophane Prismalume lens which is well-known for its excellent brightness control and efficiency. Hector was engineered so that side panels produce low contrast with the ceiling and lens providing maximum comfort. **Lighting Dynamics, 802 W. Whittier Blvd., Whittier, Calif.; or Lighting Dynamics, 8700 Ambassador Row, Dallas, Tex.**

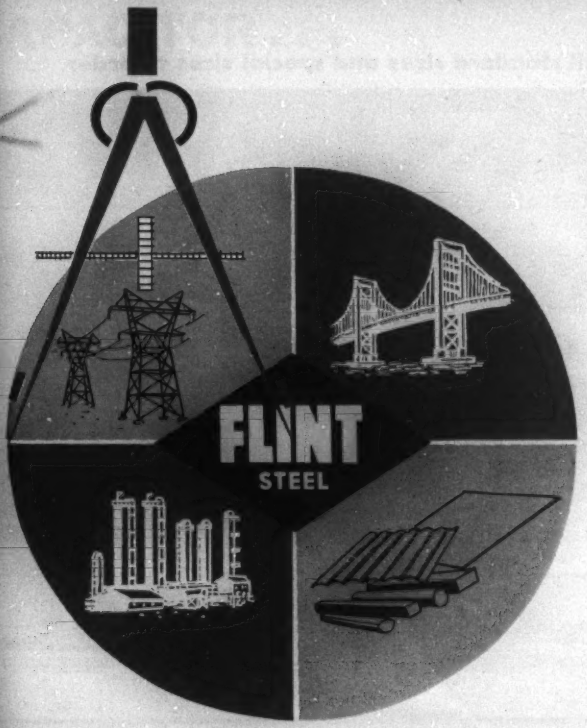
Circle 210 on the card.

New Scanning Control . . .

As many as 24 stations may be monitored in sequence with this scanning control. An abnormal condition at any point is instantly indicated by a red warning light atop the control and by an alarm, if one is wanted. In addition, the equipment being monitored may be shut down if this is desirable. For quick trouble-shooting, the number of the station affected is shown in a Burroughs tube. **Assembly Products, Inc., 13 Paul, Chesterland, Ohio.**

Circle 211 on the card.

(*Continued on page 23A*)



Fabricated Structural Steel and Fabricated Reinforcing Steel for Bridges, Commercial and Industrial Buildings: Schools, Hospitals, Power Plants, Coal Washing Plants.

Galvanized Structural Steel for Electrical Transmission Towers and Substations.

Carbon Steel Warehouse Products: Structural and Bar Shapes, Plates, Hot and Cold Finished Bars, Construction Products.

Pressure Vessels fabricated to the ASME Code from Carbon, Alloy, and Alloy Clad Steels for the Chemical and Petroleum Processing Industries.

At Flint, four distinct divisions,

FABRICATED PLATE

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for over 40 years

FLINT STEEL CORPORATION

TULSA . . . MEMPHIS

Structural steel can now be delivered promptly and when required.

For more information circle 19 on reader service card.

New Products

(Continued from page 20A)

Geiger Counters . . .

These nonphotosensitive all-glass halogen quenched geiger counters have transparent, patented, nonmetallic conductive cathode surface. Thin glass walls permit high beta radiation transmission. Counters are available in seven different models. **Radiation Counter Laboratories, Inc., Nucleonic Park, Skokie, Ill.**

Circle 212 on the card.

360° Transistor Inspection . . .

A transparent plastic container, designed to provide greater protection and ease of handling for short-lead transistors has been introduced by the Sparks Corporation. The new package which holds 100 transistors can be used for shipping, storage, and display of finished items, or for handling of units during the various stages of production. Because it holds each transistor individually and permits viewing of the contents from all angles, the new package simplifies many problems in inventory and inspection. **Sparks Corporation, 4111 Pechin St., Philadelphia 28, Pa.**

Circle 213 on the card.

High Resolution Rotary-Prism Camera . . .

An improved version of the Photo-Sonics rotary-prism high-speed 16-mm recording camera offers full-frame motion pictures at speeds to 1,000 frames per second, and performs under extremes of temperature and vibration. Light and compact, it offers important advantages in missile recording, track sled recording, aircraft flight testing, and industrial analysis. Called the *1B*, the new camera maintains picture quality even at high frame rates by means of a rotary prism and disk shutter which turn in synchronism with the continuously moving film. The prism provides image compensation and the disk shutter, located between prism and film, produces even exposure and high-image resolution. A folder which describes the camera fully is available. **Traid Corporation, 17136 Ventura Blvd., Encino, Calif.**

Circle 214 on the card.

Polyclad-Insulated Magnetic Cores . . .

A polyclad aluminum-boxed Hipermag toroidal core for magnetic amplifier applications is now available. The new resin insulation eliminates core taping and provides an hermetic seal. For shock resistance, the cores are sealed in a specially designed aluminum box and filled with a suitable damping medium. **Westinghouse Electric Corporation, Box 2099, Pittsburgh 30, Pa.**

Circle 215 on the card.

(Continued on page 28A)

AVAILABLE NOW...

in all standard sizes and special sizes to order

The New ARNOLD 6T Aluminum-Cased Tape Cores

give you 4 BIG ADVANTAGES... *at no added cost!*

(1) NEW COMPACTNESS in Aluminum-Cased Cores permits you to design for greater miniaturization, yet retain the distortion-free strength of an aluminum case that resists winding stresses. Overall dimensions are smaller than older types of aluminum cases and comparable in size with plastic-cased cores.

(2) HERMETICALLY SEALED, with Built-in Protection against shock and vibration, Arnold 6T Cores provide the most complete protection against deterioration of magnetic properties available on the market. Strain-sensitive core materials are completely surrounded by an inert shock absorbent, hermetically sealed within the cases. Trouble-free performance is virtually assured, even over long standby periods. 6T Core design further guarantees that you can vacuum-impregnate your coils.

(3) 1000-VOLT BREAKDOWN *GUARANTEED!*
The Arnold 6T Core employs a strong, inert covering with ha gloss finish which carries a 1000-volt breakdown guarantee. Su able radii and the elimination of sharp corners insure agai cutting the winding wire's insulation. Its hard non-cold-flowi finish protects the covering against cuts. Both features guaran against shorted wiring.

(4) MEETS MILITARY "SPECS" for Operating Temperatures er Temperature Rise.
The Arnold 6T Core fully meets the requirements of milit specifications Mil-T-5383 or Mil-T-7210, wherever applicab These specifications call for case construction to withsta ambient temperatures to 170° C, and a 25° C temperature ri

Arnold 6T Tape Cores are available in all standard sizes, and special sizes may be made to order... all guaranteed for size, hermetic seal, dielectric strength and temperature of operation.

● **We'll welcome your orders for prompt delivery of pilot or production quantities.**

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Boston: 49 Waltham St., Lexington · Los Angeles: 3450 Wilshire Blvd.

New York: 500 Fifth Ave. · Washington, D.C.: 1001 15th St., N.W.

For more information circle 20 on reader service card.

CAPACITOR . . .

for Every Serial Number

Give us the serial number of a Varex capacitor, and we can quickly tell you its life story . . . the source, type, and lot of raw materials . . . the day it was made . . . the crew that made it . . . the processing record, including a log of the evacuation procedure . . . the final factory tests and the results.

All this information has been compiled on a data processing card for each capacitor.

You may be interested in knowing how such a system results in a better capacitor for you. For one thing, it provides a complete master check on every production detail, helps immensely in operating a successful quality control program.

It also fixes responsibility. Every supplier of material, every O-B employee knows that what he contributes to a Varex unit is a matter of record.

It also provides a sound, precise fund of knowledge for making product improvements in an orderly way. If we change a material or process, even slightly, we can pinpoint the effect immediately and evaluate the results during the factory testing program.

When it's necessary to correlate factory procedure with field performance, it's much easier when we have complete case histories on each capacitor.

At the moment we sincerely believe you're getting the best capacitor available when you buy Varex. But we know there is always room for improvement, in any product. That's why we're doing everything possible, and individual product identity is just one phase, to make sure these improvements come as fast as possible!

OHIO BRASS COMPANY, MANSFIELD, OHIO

Ohio Brass

Evacuation procedure is logged carefully; log becomes part of a permanent record.

Final electrical tests build fund of fundamental knowledge from which we can proceed to improve the product.

For more information circle 22 on reader service card.

SHAWMUT'S TIME-TESTED SILVER-PLATED

Tri-onic

(Dual-Element)

The General Purpose Fuse

*Interrupting Capacity 25,000 Amps. A.C.

KEEPS MOTOR CIRCUITS SAFE

This is the first low voltage fuse with a published interrupting capacity of 25,000 Amps. (15,000 Amps. more than required by U.L. Standard for fuses.) For real protection use it in place of all ordinary types of fuses.

TRI-ONIC* GIVES 3-WAY PROTECTION

1. **HIGHER INTERRUPTING CAPACITY.** 25,000 A. @ 250 V & 600 V. Handles short-circuits 2½ times larger than ordinary fuses. Expands fuse application into 25,000 Amp. zone. Use it on bus plug-in duct, bus-ways, feeders, motor control panels, branch circuits.
2. **LONG TIME-DELAY.** Safely starts heavily loaded motors without blowing. Prevents circuit "outage" caused by heavy motor-starting currents or load swings. Provides "matched" protection for your motors.
3. **COOLER OPERATION.** Runs cool because of silver-plating and low I^2R losses throughout. Opens at 286° F, or 500° lower than ordinary zinc links. Ideal for distribution and panel boards, motor branch circuits, knife and enclosed switches.

* U.S. Patent Nos. 2,111,749 – 2,300,620 2,321,711

Insist on TRI-ONIC. Ask for TRI-ONIC Bulletin today.

© The Chase Shawmut Co. 1958

Tri-onic – "Awake At The Switch"

THE **CHASE-SHAWMUT CO.**

374 MERRIMAC STREET • NEWBURYPORT, MASSACHUSETTS

Subsidiary of I-T-E CIRCUIT BREAKER CO., Philadelphia, Pennsylvania

Est. 1893

Tri-onic® C-O-T® TRIONIC® C-O-T

For more information circle 23 on reader service card.

New Products

(Continued from page 23A)

First Aid Kits . . .

A line of heavy-duty unit first-aid kits designed to facilitate emergency treatment through the use of unit-wrapped items, boldly labeled and arranged for immediate recognition and access has been announced. Each kit has a facsimile index on the inside of the case lid which shows at a glance the exact location of all items and gives concise instructions for their use. The index also serves as a positive inventory control, since any missing items can be quickly identified from the facsimile table. Complete information may be obtained by requesting Bulletin *305*. **General Scientific Equipment Co., 7516 Limekiln Pike, Philadelphia 50, Pa.**

Circle 216 on the card.

Weatherproof Fluorescent Ballast . . .

The new Nor'easter is said to be completely weatherproof, and guaranteed against service failure caused by weather conditions for 2 years. The new models, all one-case construction, are considered ideal for highway lighting, area lighting, billboards, and plastic signs, and are available for 800-, 1,400-, and 1,500-milliampere lamps. **Jefferson Electric Co., 25th and Madison Sts., Bellwood, Ill.**

Circle 217 on the card.

Dual Preset Counter . . .

A dual preset counter-controller has been introduced. The new instrument is designed to solve control problems such as motor overspeed, shearing to length, high-speed coil winding, weighing, sorting, packaging, metal forming, computer timing and programming, and variable pulse generation. **Computer Measurements Corporation, 5528 Vineland Ave., North Hollywood, Calif.**

Circle 218 on the card.

Streamlined Television Transmitter . . .

A space-saving, economical transmitter for medium-coverage television stations, or as a standby unit for high power systems has been announced. Designed primarily for very high frequency television stations with effective radiated power requirements ranging from 2 to 20 kw, the *TT-2BH* is said to provide excellent performance for both monochrome and color television broadcasting. **Broadcast and Television Equipment Department, Radio Corporation of America, 30 Rockefeller Plaza, New York 20, N. Y.**

Circle 219 on the card.

(Continued on page 30A)

HOLOPHANE

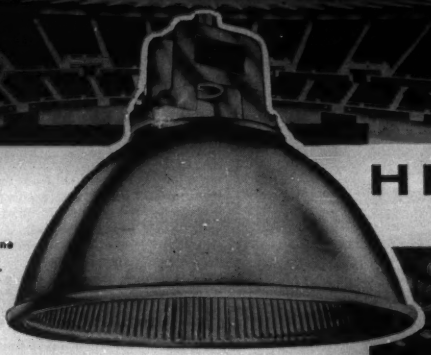
Lights the

BIG JOBS

A

HIBAY® Reflectors

For Every Type of High-Mounting Area



Holophane No. 640 Series...

B

Holophane engineers are constantly developing new and better equipment for all light sources... Here are some outstanding examples of Holophane *controlled* lighting—by the acre...In every instance one can see clearly for thousands of feet—with a maximum of visual comfort...Reason: the installation of Holophane HIBAY Reflectors... Advantages: prismatic design produces greatest utilization of illumination; metal covers protect reflectors; simplified construction assures easy installation and economical maintenance... Consult Holophane engineers, through architects and professional advisors, without obligation.

C

HOLOPHANE COMPANY, INC.

Lighting Authorities Since 1898

342 Madison Ave., New York 17, N.Y.

THE HOLOPHANE CO., LTD., 418 KIPLING AVE. SO., TORONTO 14, ONT.

For Better Lighting — Holophane — Be Specific

D

A. Dallas Memorial Auditorium, Dallas, Texas.
George L. Dahl, Architect & Engineer

B. Douglas Aircraft Company
Long Beach, California
Holmes & Narver, Inc., Architects & Engineers.

C. Louis Allis Company, Milwaukee, Wisconsin
Klug & Smith Co., Architects;
Uihlein Electric Co., Engineers

D. Allen County Memorial Coliseum,
Ft. Wayne, Indiana
A. M. Strauss, Inc., Architects & Engineers

ELECTRICAL ENCLOSURES*

Custom-Built by KIRK & BLUM

ONE or one thousand, from a small timer case to a huge control panel, Kirk and Blum produces all kinds of metal enclosures, quickly and economically

Complete facilities for fabrication of sheet steel, plate, light structurals, stainless, aluminum, monel, and other alloys.

Send your prints to Kirk and Blum for prompt quotation. More detailed information is available in new literature describing fabrication facilities and experience. Write to: The Kirk and Blum Mfg. Co., 3204 Forrer Street, Cincinnati 9, Ohio.

CONTRACT MANUFACTURING FACILITIES for:

Control Desks • Boiler, Turbine and Generator Control Panels • Power Distribution and Control Panels • Switch Gear Housings • Cubicles • Instrument Panels • Machine Bases • Electrical Enclosures • Breechings • Transformer Enclosures • Air Ducts • Stacks • Weatherproof Housings • Hoppers

KIRK & BLUM METAL FABRICATION

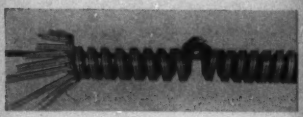
For more information circle 25 on reader service card.

New Products

(*Continued from page 28A*)

Retractable Cable . . .

Completion of a new type of cable has been announced. This is a multiconductor, multicolored retractable cable with the winding direction reversed in the middle of its length. When the cable is extended, the twisting forces are transmitted to the reverse point, with the result that



no strain is put on the wires where they terminate. The inductive effect is also reduced by this method. Many different gauges and numbers of wires can be fabricated by this method. Details can be obtained by writing to John Ford, Sales Manager, **Organic Development Corporation, P. O. Box 415, Garden Grove, Calif.**

Circle 220 on the card.

Semiconductor Products Introduced . . .

The largest group of new semiconductor products ever announced at one time by Texas Instruments Incorporated has been introduced. Included are a Sensistor silicon temperature probe with a positive temperature coefficient which enables it to measure accurately minute temperature variations, and a higher frequency high-power diffused base germanium transistor, the *2N1046*, designed for computer core driving and cathode-ray tube deflection applications. A transistorized fully portable television set and two palm-size radio transceivers were designed and built to illustrate advanced applications made possible with the new semiconductor devices being introduced. **Texas Instruments Incorporated, P. O. Box 312, Dallas, Texas.**

Circle 221 on the card.

Load Break Lever . . .

A simple, low cost, mechanical load break can be attached, in a matter of minutes, to any Hubbard Faultmaster cutout regardless when installed. When equipped with this load break lever the Faultmaster cutout becomes a safe, positive load interrupter under any rated load. Operation is simple and easy. It is safe because lineman's spurs are more deeply embedded with the upward thrust of the hook-stick which maintains tight, positive contact with load break lever. The upward thrust of the hook-stick breaks fuse inside tube for safe, positive interruption. **Hubbard and Company, 200 S. Michigan Ave., Chicago 4, Ill.**

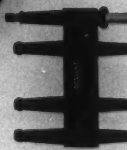
Circle 222 on the card.

DOSSERT UNDERGROU CONNECTOR

the versatile lin

featuring:

- Fully molded, no factory taped joints.
- Insulated with MYPAR* rubber for higher quality and longer life, or MYPRENE* rubber for higher temperature resistance, and greater resistance to acids and oils.
- Made of high conductivity copper, insuring cool operation.
- Interchangeable with all standard underground connectors and their component parts.
- Made to fit standard compression tools.



Insulated Cra Connector type CBR

Limiter Link Assembly type LLA

Terminal Lug type DPL

Comp. Coup type DPC

*U.S. Reg. Trade Mark

Write for illu

50 YEARS OF TECHNICAL LEADERSHIP

DOSSERT MFG. C

249 Huron Street, Brooklyn 22, N. Y.

Representatives in all principal cities

For more information circle 32 on rea

UND
RS....
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MICON* type MC

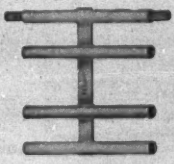
MICON COMPONENTS

Tapered Compression Sleeve type C

Cable Receptacle type MA

Insulating Sleeve for MICON Outlet type MIS

Crab
or
R



Uninsulated Crab Connector type CBN

MICON Stud Connector type MCBS

Limiter Link Assembly type NLRA

oupler
PC

Comp. Tee Coupler type CRT

illustrated catalog. →

CORP.

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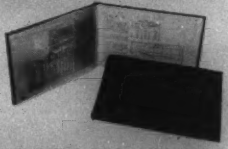
FREE!...

to qualified *Designers, Engineers, Metallurgists*

TECHNICAL SURVEY



HIGH-CONDUCTIVITY OXYGEN-FREE COPPER

If you are concerned with the electrical properties of copper, you'll find "Technical Survey of OFHC® Brand Copper" invaluable. It's the authoritative text you need at your fingertips for comparative data on OFHC and other types of copper. Topics include:

- **nature of OFHC Copper**
- **physical characteristics when unalloyed**
- **physical characteristics dependent on condition**
- **effects of impurities and alloying elements**
- **metallography, methods of analysis and testing**

Tables, charts, and illustrations provide clear, accurate pictures of every topic covered. You'll find this 122-page book—handsomely hardbound in the finest water- and chemical-resistant buckram—a constant reference source, a valuable addition to your technical library.

"Technical Survey of OFHC Brand Copper" contributes much to metallurgical literature, being the first complete, definitive work on this exceptionally high-grade metal. Published by AMAX as a service to Industry, the book is offered *free* to qualified people in the electrical equipment field.

For your free copy, simply fill out the attached form and mail it to us. Of course there is absolutely no obligation.

Technical Service Department

AMERICAN METAL CLIMAX, Inc.

61 Broadway, New York 6, New York

AMAX

Yes! I would like to own "Technical Survey of OFHC Brand Copper." I understand that the book is free and there is absolutely no obligation. Please send my copy to:

NAME.....

POSITION.....

COMPANY.....

ADDRESS.....

.....

(Offer good only as long as supply lasts.)

Circle 33 on reader service card.

INDUSTRIAL NOTES

New Miniature Lamp Division. A special process and miniature lamp division has been formed by Silvray Lighting, Inc., Bound Brook, N.J. The new division will be concerned with the development and sale of reflectorized lamps that precisely control light direction and give desired patterns of light.

Plastic Rotor in Switch Redesign. Electrical and mechanical properties of a halo-fluorocarbon plastic rotor played a large part in the redesign and development of a new and smaller rotary switch for military applications, it was announced by Oak Manufacturing Co., Chicago, Ill. Used for multiple circuit selection, the switch, which is $1\frac{9}{32}$ inch in diameter, is employed in the miniaturization of military communications, navigation, and detection equipment. Intended for a wide variety of electrical applications, Kel-F resins are a development of the Chemical Products Group, Minnesota Mining and Manufacturing Co., 900 Bush Ave., St. Paul 6, Minn.

Revere Electric Moves. Another milestone in the growth of Revere Electric Mfg. Company was passed when the firm moved into a new, modern plant at 7420 Lehigh Ave., Niles, Ill., a northwest suburb of Chicago. The move gives Revere, a manufacturer of industrial and commercial outdoor lighting equipment, approximately double the floor space of their former plant. The 10-acre site upon which the new plant is situated will allow for additional future expansion as necessary.

Gold Strip for Hi-Fi Recording. To produce the high-fidelity response of modern stereo and monophonic recording heads, a gold alloy strip only 80 millionths of an inch thick, 40 times thinner than a human hair, has been developed. It is now in commercial production at the plant of the American Silver Company, 36-07 Prince St., Flushing 54, N. Y. The 80-millionths-thin gold is free from pin-holes, hard, and noncorrosive, as well as nonmagnetic.

Extruding and Calendering Silicone Sponge. Complex silicone sponge shapes now can be extruded and calendered by an exclusive technique perfected by The Stalwart Rubber Company, 194 Northfield Rd., Bedford, Ohio. Silicone sponge also provides unparalleled resistance to aging, sunlight, ozone, oils, and chemicals, plus excellent dielectric qualities at extremely high temperatures. Lower equipment costs coupled with high-volume production economies in extruding and calendering silicone sponge provide customers with sharply reduced production costs. Costs of extrusion dies for silicone sponge sections are only a fraction of those for conventional steel or aluminum molds. Special dies for extruding silicone sponge can usually be developed by Stalwart engineers for less than $100. Write for samples and complete information.

Underground Steam Lines. Savings of up to 50% over the cost of constructing underground steam lines by conventional methods are promised by a new system announced jointly by Consumers Power Co., Jackson, Mich., and Badger Manufacturing Co., Cambridge, Mass. following an 8-month service test. In most applications the new pipe-laying and insulating system eliminates the need for costly concrete conduit and manholes. Additional information on this new steam line construction method is available from Badger Manufacturing Company, 230 Bent St., Cambridge, Mass.

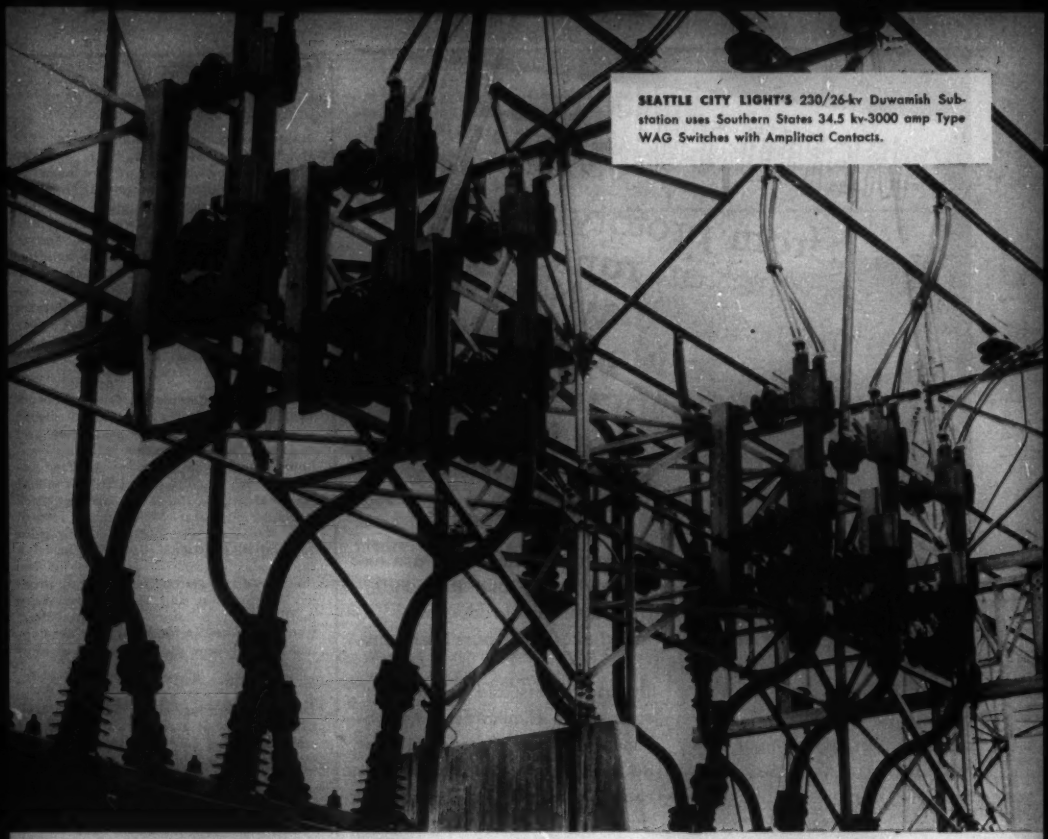
Computer Designed Pulse Transformers. Complete designs for pulse transformers for radars, pulse generators, and other high-frequency equipment can now be produced by computers in minutes, where hours and weeks were required previously. Announcement of the new technique was made by Westinghouse Electric Corporation, Box 2278, Pittsburgh, Pa. The development is significant to users of pulse transformers in many ways: the speed advantage enabling quicker delivery, consistency of designs, assurance of design quality, and computers can be used at the negotiation stage to give users specific design information quickly.

Temco. Two radically new processing developments by Temco Aircraft Corporation, P.O. Box 6191, Dallas 22, Tex., are expected to provide better stainless steel honeycomb panels for weapons of the future, company officials have announced. One of them is called Temcombing and is a continuous process of fabricating stainless steel sandwich. The other is a simplified two-stage process for brazing such honeycomb structures. Patents are being applied for on both systems. The Temcombing process has a brazing cycle time of 3 to 20 lineal inches per minute, depending on panel thickness, and will produce panels up to 4 feet in width and 10 feet or greater in length. The processes provide a much more efficient method of producing airframe components for supersonic weapons systems now being developed in both the piloted and pilotless vehicle fields.

New Dri-Stat Paper. Greatly increased resistance to fogging in bright sunlight and under high-intensity fluorescent lights is provided by a new Bright-Light No. 1 negative paper which has been developed by Peerless Photo Products, Inc., Shoreham, L. I., N. Y., for its Dri-Stat office photocopying system. The new Bright-Light paper now has an extra shield against ultraviolet rays built right into the emulsion. This shield is provided by a special yellow pigment which is mixed into the emulsion before it is coated onto the paper stock.

Datex. The Giannini Datex Division has become the Datex Corporation, a subsidiary of G. M. Giannini & Co., Incorporated, 1307 S. Myrtle Ave., Monrovia, Calif.

(Continued on page 46A)



SEATTLE CITY LIGHT'S 230/26-kv Duwamish Substation uses Southern States 34.5 kv-3000 amp Type WAG Switches with Amplitact Contacts.

The Man-sized Switch for Man-sized Jobs

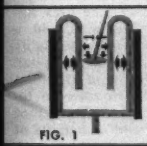


FIG. 1

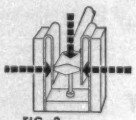


FIG. 2

AMPLITACT® CONTACTS ON WAG

High pressure Amplitact contacts provide maximum dependability under high current short-circuit conditions. The arrows in Fig. 1 show direction and relative magnitude of electromagnetic forces induced when switch is subjected to fault current.

The resultant electromagnetic forces, as shown in Fig. 2, greatly increase contact pressure and positively hold blade in the engaged position. For complete details, write for Bulletin 56AM on the Amplitact.

"Don't send a boy to do a man's job" is a saying especially applicable when choosing switchgear that must safely carry 3000-4000 amperes. Not only must it be capable of carrying such loads after years of service, but it may be called on to withstand fault currents up to 120,000 amperes without damage.

It's a man-sized job. Dirt, industrial waste, years of exposure to every type of contamination make the job even tougher. It takes a man-sized switch!

The Type WAG illustrated above is a good example. It's big and tough enough to carry its rated load continuously without excessive temperature rise. A built in safety factor more than compensates for the deteriorating effects of long, hard service. Amplitact® contacts provide high pressure for handling the heaviest faults.

The WAG is finding wider and wider acceptance in all ratings. It's now in service in virtually every state in the union.

Get complete details from your Southern States representatives or write direct for our latest bulletin.

LIVE BETTER ELECTRICALLY

SOUTHERN STATES EQUIPMENT CORP. HAMPTON, GEORGIA

IN CANADA: Dominion Cutout Co., Ltd., Toronto

MEMO TO: ENGINEERING AND PRODUCTION DEPARTMENTS

. . . from prototypes to production runs . . . wire harnesses may now be preassembled without worry of incurring high re-work costs in case of wire changes.

The assembly of wire harnesses has always been a major headache to production departments . . . final production of electrical and electronic equipment is many times held-up because of a lack of assembled harnesses . . . a costly proposition brought on by the hesitation to pre-produce wire harnesses because of unforeseen, but sure to come, wire changes. In fact, 4 out of 5 wire harness designs are changed after they reach the production department for one or more of the following reasons . . . faulty design, wireman's mistake, customer amendment, or changes to include a new component. Re-work costs on laced wire harnesses are extremely costly and it is understandable that production is delayed until the last possible minute.

The use of "Insuloid Cradleclips" completely eliminates this problem . . . wire harnesses can now be one of the first components ready for final production. If changes occur, you merely open the "Cradleclips," remove or insert wires and re-fasten the "Cradleclips" . . . it's fast, easy and economical. No waste material . . . labor costs are minute. The use of "Cradleclips" could save your firm at least 52% of your yearly wiring costs.

WIRE BETTER, FASTER AND MORE ECONOMICALLY

with the Insuloid cradleclip WIRING SYSTEM

TRADEMARK

Tests conducted by an independent Time Study organization provide positive proof of the great savings of time and materials that can be realized through the use of "Insuloid Cradleclips" in the assembly of wire harnesses. Free copies of this report are available . . . write today for your Time Study Report and free "Cradleclip" samples . . . there's no obligation of course.

a product of

ELECTROVERT INC. 124 EAST 40TH ST. • NEW YORK 16, N. Y.

For more information circle 39 on reader service card.

Industrial Notes

(Continued from page 40A)

Name Change. Gulton Industries, Inc., 212 Durham Ave., Metuchen, N. J., officially announces the changing of the name of its Glennite Instrumentation Division to the Gulton Instrumentation Division. Glennite is the company's registered trade mark and includes components, instruments, and equipment produced by other divisions of the company. Misunderstanding has arisen in sales and literature inquiries in which information is requested on Glennite products that are not necessarily marketed by the new renamed Gulton Instrumentation Division.

New Facilities Completed. Genesys Corporation, manufacturers of advanced control computer systems for the petroleum and chemical process industries, has announced the completion of its Los Angeles, Calif., facilities. Located at 10131 National Blvd., the new modern brick structure contains 10,000 square feet of floor area. Extensive interior modifications resulted in functional development laboratory and manufacturing space for the company's systems engineering and product development staff. A complete micro machine shop is housed in a special dust-free laboratory devoted to the development of precision electromechanical components.

Highway Lighting and Nighttime Accidents. Results of a recent 2-year study of traffic accidents and fatalities on a 3-mile stretch of urban highway have provided striking new evidence of the important role that adequate highway lighting plays in the reduction of nighttime traffic accidents. A 32% reduction in night accidents, a 38% drop in property loss, and the elimination of after-dark fatalities were brought about by the installation of modern highway lighting equipment, the study revealed. Conducted by the Indiana Highway Department and Indiana State Police, the test covered a 1-year period prior to installation of lighting and a similar period following installation. The area singled out for the study was on US 40, a typical urban highway located near highly populated Indianapolis, the state capital. To light the 3-mile segment of US 40, a total of 176 General Electric filament luminaires were mounted at intervals of approximately 125 feet and at heights of 30 feet.

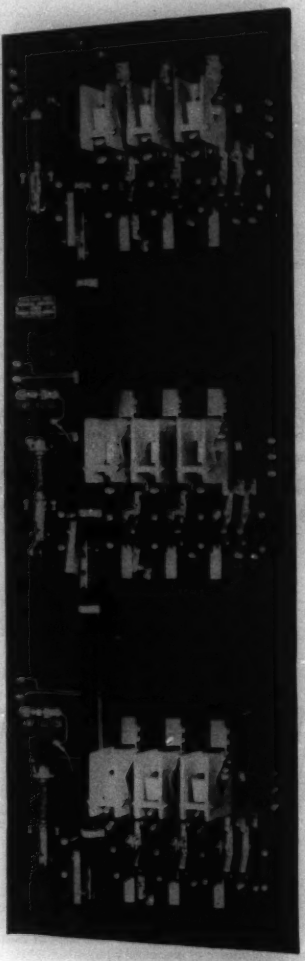
New Approach to Heat Processing. Ovens may become obsolete for some types of industrial heat processing as a result of developments by Research, Incorporated, 115 N. Buchanan Ave., Hopkins, Minn. A new heating system employs high-intensity radiant heat lamps which literally shine heat energy into the object being heated. Transmission rates up to 100 kw (or 6,000 Btu/sec) per square foot have been achieved. Since no enclosure is required, the heating can take place wherever sufficient electric power can be applied, a distinct advantage when the work to be heated is not easily moved or confined.

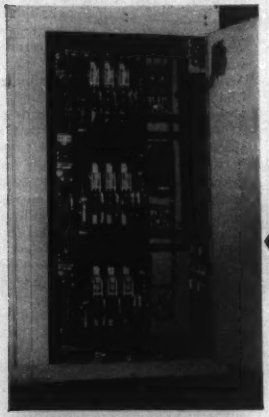
now... multiple mechanical interlocking extends electrical control design frontiers

Any Number of Mechanically or Magnetically Held Switches Can Be Mechanically Interlocked... Simply and at Low Cost

Mechanical interlocking involving more than two devices has until now been expensive and complicated. Now . . . for simplification and safety in control systems, ASCO provides low cost mechanical interlocking through a simple, effective cable interlock, suitable for controlling any number of switches.

In this installation, three ASCO Mechanically Held Remote Control Switches are mechanically interlocked through a slack cable interlocking system. Closing of any one switch removes slack from aircraft cable connecting the switch shafts, effectively interlocking the remaining switches. Should either of the two remaining switches then be energized, the connecting cable prevents closure.





This application shows ASCO triple interlocked Bulletin 911-163s Remote Control Switches used for switching the primaries of transformers feeding 800, 1000 and 1200 volt fluorescent lighting circuits. On the job in vital areas of New York's Lincoln Tunnel, this system compensates for changes in ambient temperature and for lamp aging.

Dependable Control by ASCO

Write today for catalog 57-52 on ASCO Remote Control Switches— it is your basic reference on dependable electromagnetic control.

Automatic Switch Co.

50-K Hanover Road, Florham Park, New Jersey • FRontier 7-4600

AUTOMATIC TRANSFER SWITCHES • SOLENOID VALVES • ELECTROMAGNETIC CONTROL

For more information circle 43 on reader service card.

ASCO®

DIELECTRIC TEST EQUIPMENT *by* BIDDLE

...for d-c tests at voltages up to 100 KV

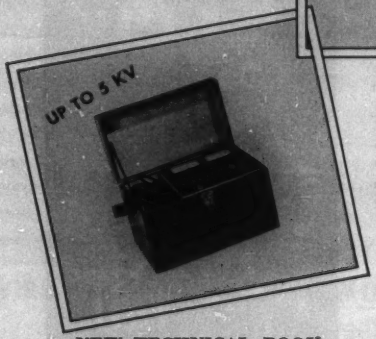
IMPORTANT FEATURES

- Well-designed provisions for utmost safety
- Simple operation and reliable performance
- Excellent output voltage regulation
- Compact, mobile design
- Facilities for voltage and leakage current measurements

IMPORTANT USES

Development—to test d-c dielectric strength of insulating materials and the adequacy of the electric design of insulation in equipment.

Production—for non-destructively detecting defects in electrical insulation.

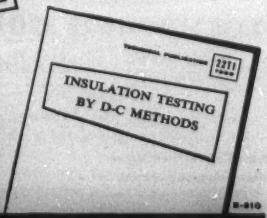


Maintenance—and preventive maintenance—for non-destructively detecting unreliable condition of electrical insulation in new or repaired equipment.

NEW TECHNICAL BOOK

A new technical treatise by E. B. Curdts, Director of Engineering, James G. Biddle Co., contains a wealth of pertinent data for the engineer interested in insulation maintenance of electrical equipment.

Copies are available at $2.00 each. Orders should be made on your company's letterhead accompanied by check to the order of the James G. Biddle Co. Ask for Publication 22T1EE.



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ELECTRICAL TESTING INSTRUMENTS • SPEED MEASURING INSTRUMENTS
LABORATORY & SCIENTIFIC EQUIPMENT

For more information circle 44 on reader service card.

TRADE LITERATURE

Electron Microscope Folder. A 6-page folder containing engineering information on the Norelco *EM-100B* electron microscope is available gratis from the Instruments Division, Philips Electronics, Inc., 750 S. Fulton Ave., Mount Vernon, N. Y. Text covers construction details, electron optical system, electron source, condenser lens, objective lens, and intermediate lens systems.

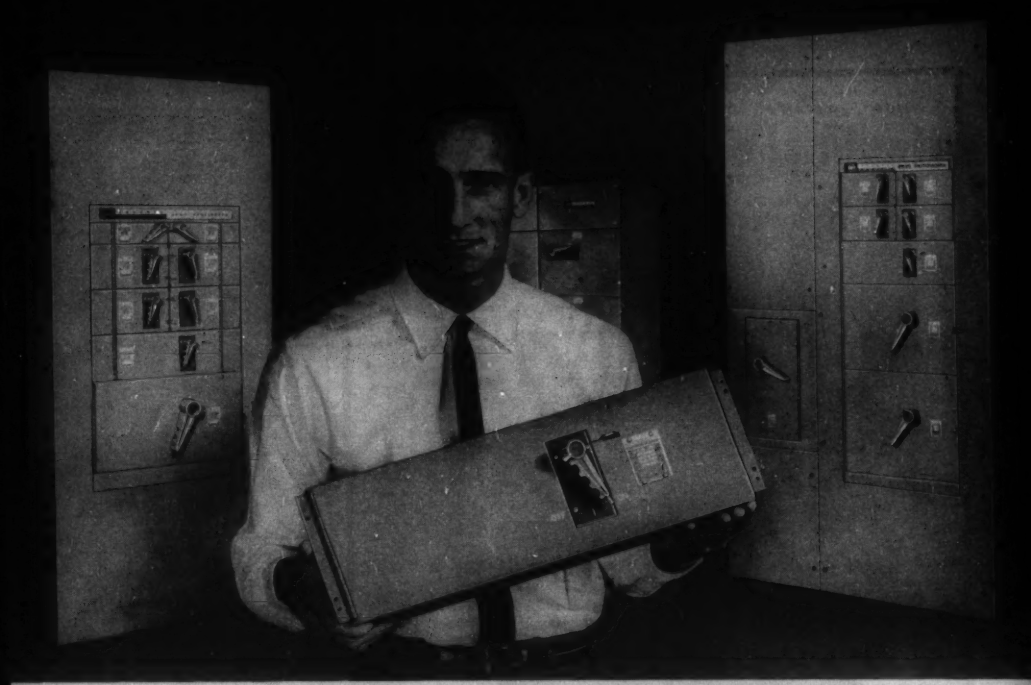
Heater and Air Conditioner Bulletins. Eight-page bulletin *286*, describing a new line of automatic gas-fired unit heaters, is available from Ilg Electric Ventilating Company. Also available are complete specifications and construction data on a new line of self-contained, air-cooled air conditioners. Bulletin *2800* gives complete details of these. Write Ilg Electric Ventilating Company, 2850 N. Pulaski Rd., Chicago 41, Ill.

Configuration and Voltage Chart. To simplify the identification, selection, and ordering of the correct types of plug caps and electrical receptacles for specific amperage and voltage requirements, The Arrow-Hart & Hegeman Electric Company, has made available unique, new "Configuration and Voltage Charts." Clearly diagramming the approved and standardized receptacle openings and plug blade arrangements of 28 different types of polarized, non-polarized, and grounding devices for 2-, 3-, and 4-wire installations, these charts are offered in 17 inch by 22 inch wall size and 8½ inch by 11 inch catalog page size. Diagrams include voltage and amperage ratings for each type of device and also show the company catalog numbers for typical wiring devices. Copies of the Configuration Charts in the catalog page size can be obtained free of charge by writing to The Arrow-Hart & Hegeman Electric Company, 103 Hawthorn St., Hartford 6, Conn.

Low Drift Vibrating Reed Capacitance Modulator Literature. Built to rigid commercial specifications for applications involving long-term stability, this capacitor's industrial uses include electrometers, radiation detectors, ionization chamber amplifiers, Ph meters, mass spectrometers, stable process control equipment, etc. One of the outstanding features of the vibrating capacitor is the fact that drift never exceeds ±0.2 millivolts per day, noncumulative. This makes it suitable for use in process measurement and control apparatus where stable performance without recalibration is necessary for periods of a month or more. Stevens-Arnold Incorporated, 7 Elkins St., South Boston 27, Mass.

Facilities Brochure. This 43-page, substantially illustrated brochure is now available from Electronic Communications Inc., 1501 72nd St. N., St. Petersburg 10, Fla. The brochure is to acquaint the reader with the new facilities in St. Petersburg, Fla. following the company's move from Teterboro, N. J.

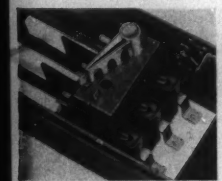
(Continued on page 54A)



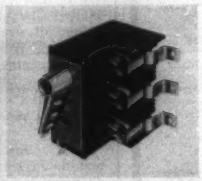
Now QMQB Fusible Switches

- **QUICK-MAKE, QUICK-BREAK**
- **30 THROUGH 1200 AMPS**
- **VISIBLE BLADE CONSTRUCTION**

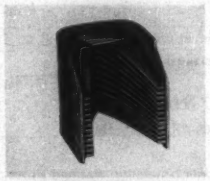
FOR PANELBOARDS, SWITCHBOARDS, CONTROL CENTERS —heavy-duty design meets modern industry's increased power handling requirements — 30 through 1200 amperes, 600 volts — the most complete line available! U.L. approved. For complete information on QMQB units and panelboards, write for bulletin 3-230: Federal Pacific Electric Company, General Offices: Newark, New Jersey.



VISIBLE BLADES FOR MAXIMUM SAFETY—Lets you see at a glance whether switch is "ON" or "OFF"—makes inspection easy. Silver-alloy contacts insure positive connections—reduce wattage loss.



INTEGRAL HANDLE MECHANISM FOR GREATER CONVENIENCE—handle mechanism and switch are combined in a single unit—eliminates excess linkage—prevents misalignment and false indication of switch position.



DEIONIZING ARC QUENCHERS FOR COOLER, FASTER INTERRUPTION—eliminate pitting and provide higher interrupting ability. Arc is divided, cooled, and extinguished in the quencher, rather than on the contact surfaces.

HIGH PRESSURE FUSE HOLDERS FOR LONG LIFE, RELIABLE SERVICE—grip the fuses tightly under constant spring pressure—reducing contact resistance for cooler, more efficient switch operation—even under varying loads.

LOCKING PROVISION FOR ADDED SAFETY—cover may be locked in either "ON" or "OFF" position with as many as three full-size padlocks to prevent unauthorized access. Additional provision for padlocking cover.

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THERE IS A REASON...why *CHRISTIE* was selected as the principal source of D-C Power Supplies for all the above projects... **RELIABILITY**

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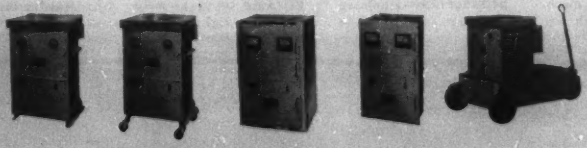


For more information circle 46 on reader service card.

Trade Literature

(*Continued from page 52A*)

Temperature Detector Catalog. Complete information about thermohm detectors (resistance thermometers) for temperatures up to 1,000 F is now available in a 36-page Catalog *EN-54*. This new publication describes how these primary elements are being used for many applications in ceramics, chemicals, foods and drugs, glass, metalworking, petroleum and refining, and steam and power generation. For a copy of Catalog *EN-54*, "Thermohm Temperature Detectors—Assemblies, Parts and Accessories," write Leeds & Northrup Company, 4934 Stenton Ave., Philadelphia 44, Pa.

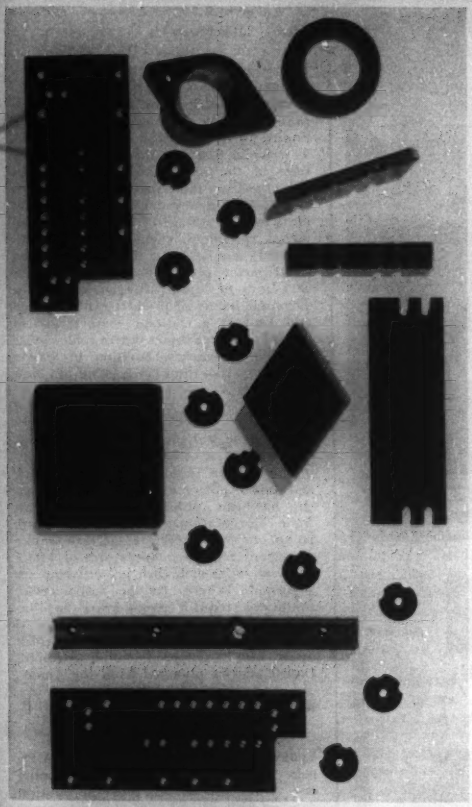
Acetate Tape Booklet. A 4-page booklet, intended to aid designers in selecting acetate tapes, lists physical and electrical properties of Scotch brand acetate tapes, as well as the military specifications met by the tapes. Physical and electrical data are listed in a cross-reference chart complete with recommended temperatures for curing thermosetting adhesives. A front-page chart lists the upper temperature limits of each tape by number and the military specification met by the tape. Other sections deal with solvent and moisture resistance, electrical purity, dielectric strength, film toughness, and temperature data. The booklet may be obtained by writing to Minnesota Mining and Manufacturing Co., Dept. D8-269, 900 Bush St., St. Paul 6, Minn.

Silicone Fluids Guide. An engineering guide to silicone fluids for mechanical applications has been published. It is a unique compilation of information essential to selecting the most suitable silicone fluid medium when designing for reliable uniform performance. Advance development research engineers and maintenance equipment designers will find this 8-page file-size guide a practical aid. For easy reference, the code number *3-112* has been assigned to this fact-laden piece of literature. Write Dow Corning Corporation, Midland, Mich.

Hollow-Glass Microspheres Brochure. An 8-page illustrated brochure entitled "Eccospheres" is now available from Emerson & Cuming, Inc., 869 Washington St., Canton, Mass. The brochure describes a hollow-glass microsphere product which is used as a dielectric material in molding compounds, radomes, heat barriers, foams, casting resins, and ceramics. Methods of manufacture and use are presented. Data on Eccospheres, as well as on a variety of products made therefrom, is also included.

Hydroelectric Equipment Brochure. Brochure No. *HY-51* describes cranes and equipment for hydroelectric, flood control, and water supply projects. Copies of the brochure may be obtained by writing to the Advertising Department, Yuba Consolidated Industries, Inc., 351 California St., San Francisco 4, Calif.

(*Continued on page 56A*)



Fabricated by CDF. Near the presses that produced the Dilecto laminates, these paper-base parts were machined to close tolerances by CDF specialists . . . quickly, accurately, economically for the purchasers. This is a random selection from the five grades described in the table below.

CDF Dilecto® paper-base laminates for the workhorse insulation jobs

For everyday mechanical-electrical parts that receive tough punishment and must have excellent physical and dielectric properties at low cost, the CDF phenolic paper-base line is outstanding.

Economy. CDF paper-base grades machine readily into intricate parts. Some are flame-retardant. Others are especially adaptable for punching. All are economical for the value delivered.

Fabrication Facilities. CDF has excellent and extensive plastics-fabrication facilities for turning out finished Dilecto parts to your specifications—better and more economically than you can do it yourself. Save the time and trouble of intricate fabrication by using CDF's specialized facilities.

See Sweet's, Electronics Buyers' Guide, and the other directories for the phone number of the CDF sales engineer nearest you. Or send us your print or problem direct, and we'll return a recommendation of the right Dilecto grade for your need.

CDF makes Di-Clad* printed-circuit laminates, Diamond* Vulcanized Fibre, CDF products of Teflon†, flexible insulating tapes, Dilecto* laminated plastics, Celoron* molded products, Micabond* mica products, Spiral Tubing, Vulcoid*.

*Trademark of Continental-Diamond Fibre Corporation
†Du Pont trademark for its TFE-fluorocarbon resin

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A SUBSIDIARY OF THE Bakelite COMPANY • NEWARK 86, DEL.

Typical Property Values—Dilecto Paper-Base Laminates in Sheet Form

	X-13 (NEMA X)	XP-13 (NEMA P)	XX-13 (NEMA XX)	XX-13 FR (Fire-retardant) (NEMA XX)	XXXP-28 (NEMA XXXP)
ROCKWELL HARDNESS (M SCALE)	100	95	110	108	90
TENSILE STRENGTH lw (1000 psi.)	20	12	16	17	12
FLEXURAL STRENGTH lw (1000 psi.)	27	16	17	20	18
COMPRESSIVE STRENGTH (1000 psi.)	40	25	35	41	22
WATER ABSORPTION (% in 24 hrs.) 1/16" thickness	3.5	3.0	1.4	1.2	0.6
MAXIMUM CONTINUOUS OPERATING TEMPERATURE (°C.)	120	120	120	120	120
DIELECTRIC STRENGTH perp. to lam. (VPM)	800	800	650	700	800
DIELECTRIC STRENGTH parallel to lam. (Kv.)	50	50	60	70	75
DISSIPATION FACTOR at 1 mc, Cond. A	0.042	0.038	0.034	0.038	0.027
DIELECTRIC CONSTANT at 1 mc, Cond. A	5.5	4.6	4.7	4.8	3.6
ARC-RESISTANCE (seconds)	8	4	4	10	10
INSULATION RESISTANCE (megohms) ASTM D-257, Fig. 3	100	100	1,000	1,000	600,000
AIEE insulation class	A	A	A	A	A

For more information circle 47 on reader service card.

Here's Why

GAI-TRONICS

Transistorized

COMMUNICATIONS

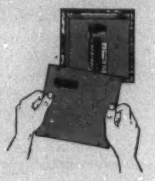
IS "TOPS"

in *maintainability*

GTC

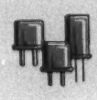
*an effective, economical industrial communication system designed to provide swift and sure voice communications regardless of distance or surrounding noise conditions.

1. Central control cabinet is eliminated.



2. Loudspeaker Amplifiers and Handset Stations are "plug-in". Untrained personnel can replace a defective unit with a "spare" in minutes. Repairs can be made at the shop bench.

3. The inconvenience and expense of vacuum tube failure is completely eliminated. Unlike vacuum tubes, transistors indicate unlimited life and no deterioration in operation.



4. Because of transistors' much lower voltage requirements, GTC operates with much greater safety factor than vacuum tube equipment.

5. Ultra-simple wiring plan (no shielded cables used).

GAI-TRONICS
CORPORATION
Dept. B
READING, PENNA.

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GTC is extremely flexible in application. Write today for a copy of our completely illustrated, descriptive booklet. It's yours free by return mail.

For more information circle 48 on reader service card.

Trade Literature

(*Continued from page 54A*)

Cryogenic Refrigerator Literature. A 4-page folder on the new Linde *LNR-25B* liquid nitrogen refrigerator is available. This folder describes the outstanding features of the refrigerator which was designed to meet the cryogenic storage needs of industry and research. The *LNR-25B* is ideal for the storage of medical and biological specimens, chemicals, and metallurgical samples and for shrink-fitting small metal production parts. It holds 28.5 liters of liquid nitrogen, and about 392 cubic inches of product can be stored and kept at a constant temperature of —320 F. For free copies of this folder write to Linde Company, Division of Union Carbide Corporation, 30 E. 42nd St., New York 17, N. Y. Ask for *F-1059A*.

Polyethylene, Polypropylene Tank Catalog. A catalog sheet, illustrating and describing its line of standard tanks in branch and linear polyethylene and polypropylene, has been published by the American Agile Corporation. The free literature points out that where average load service conditions require temperatures of 140 F and less, tanks of branch polyethylene are suggested. Where average load service conditions require temperature applications up to 220 F, linear polyethylene is recommended, whereas for temperatures up to 240 F, polypropylene is required. Copies may be obtained from the American Agile Corporation, P. O. Box 168, Bedford, Ohio.

Epoxy Glass Laminate Data Manual. A 21-page technical data manual containing test values and curves, plus specification data, on high reliability epoxy glass copper clad and unclad laminates for printed and other circuitry has been issued by The Mica Corporation, Culver City, Calif. The first half of this manual contains test data based on *MIL-P-18177A* and National Electrical Manufacturers Association (NEMA) specifications. Such factors as requisite bond strengths, flexural strengths, dielectric breakdown, dielectric constants, and the many other test values required by MIL and NEMA specifications are included. For copies, write to: The Mica Corporation, 4031 Elenda St., Culver City, Calif.

Controls Bulletins. Technical literature on United Electric Controls Co. Type *C11* and Type *E32N* temperature controls is now available. The Type *C11* is a wide-range temperature control, excellent for use in engine cooling systems and marine applications. The Type *E32N* is an indicating temperature control, and is ideally suited for such applications as ovens, incubators, baths environmental test chambers, molding machines, etc. For additional information on the Types *C11* and *E32N* controls, or for complete data on other precision-made controls, write to L. E. Pratt, United Electric Controls Co., 79 School St., Watertown, Mass.